# THE ENGINEER

APRIL 30, 1954


## British Electrical and Allied Manufacturers' Association

THE forty-third annual report of the British Electrical and Allied Manufacturers' Association, 36 and 38, Kingsway, W.C.2, was published yesterday. In its review of the year ended September 30, 1953, the Association asserts that an annual installation programme of 2000MW of generating plant is required to provide for the re-equipment of British industry, whereas present plans allow for an average annual rate of installation of no more than 1750MW during the next three years. The plant commissioned by the British Electricity Authority in 1953 totalled 1413MW, which was about 127MW less than in 1952. According to the report, the manufacturing industry is capable of supplying generating plant up to 2000MW per annum for the home market besides 1000MW per annum for oversea customers. Despite foreign competition the exports of electrical goods amounted to nearly £212 million in 1953—an average fall of about 3·4 per cent, compared with the results achieved in 1952. A more detailed comparison of the two years shows that the fall was accounted for mainly by domestic appliances (excluding fans), motors, cables, valves and batteries, and that these reductions were partly offset by increased sales of transformers, switchgear, turbines, radio lamps and locomotives. Evidence of sustained interest in the Canadian market is given in the report, which states that 630 manufacturers have made use of the facilities set up by the British Standards Institution for approving electrical equipment to the requirements of the Canadian Standards Association. Mention is also made of recent arrangements for simplifying the procedure for obtaining C.S.A. approval. In an analysis of foreign competition the report shows that the value of Western Germany's electrical exports was £105 million in 1953, compared with £89,900,000 in 1952 and £56,300,000 in 1951. It is suggested that the growth of Continental competition results from a combination of factors which include "incentives," price cutting, extended credits and shorter deliveries: reference is made to the Continental practice of quoting firm prices and of backing up delivery promises by a penalty clause. Japanese electrical exports received a setback in 1953 compared with those of 1952, but the report points out that because Japan's manufacturing capacity is expanding more rapidly than the home demand, her strength as an export competitor may be expected to increase.

## British Non-Ferrous Metals Research Association

THE thirty-fourth annual general meeting of the British Non-Ferrous Metals Research Association was held in London on Thursday of last week, April 22nd. In a statement amplifying the annual report, the chairman of the council, Hon. R. M. Preston, said that the work of the Association's electroplating section had been considerably expanded to undertake a detailed study of the operation of bright nickel plating. From that study it was hoped to secure means for controlling this operation more satisfactorily and for improving the quality of commercial plating. Long-term researches of a really basic character, the chairman continued, were still not included in the programme to the extent that many members would like to see, because of the pressure upon the Association for shorter term investigations of more immediate practical interest. There were, however, several researches in hand such as the study of the properties of grain boundaries, which were of a more fundamental character, though the scale of investigations in that class was much smaller than the research board thought desirable. Corrosion researches, the chairman added, had again figured largely in the programme, which was right and proper in the light of the importance of corrosion resistance in governing the applications of the various metals and alloys with which the Association was concerned. At a luncheon which followed the meeting the toast of "The Association" was proposed by Sir John G. Lang, K.C.B., Secretary to the Board of Admiralty. Sir John spoke of the value attached by the Admiralty to the Association's work and remarked that research was frequently the first step towards the initiation of new developments leading to superior performance and lower costs. Research also, he said, brought about the better utilisation of scarce and expensive materials. After the chairman, Hon. R. M. Preston, had acknowledged the toast, Mr. Robert Carr, M.P., proposed "The Guests." Response to that toast was made by Lord Mancroft, Lord-in-Waiting.

## Derby Firm's Jubilee

THIS year Rolls-Royce, Ltd., is celebrating the first meeting fifty years ago of the Hon. Charles Stewart Rolls and Sir Frederick Henry Royce, Bt., an occasion which two years later led to the founding of the present company. The company recalls this period particularly in some notes dealing with its history. It shows how one of the three first cars designed by Royce appeared so superior to the Continental cars which C. S. Rolls and Co. were selling exclusively that Rolls at this meeting undertook to market all he could make. These three cars had two-cylinder engines and developed 10 h.p. for a weight, including a three-speed gearbox, of 14½ cwt. Rolls immediately impressed Royce with the demand for a fashionable car having a bigger and, hence, more reliable engine, and by 1907 he had developed the "Silver Ghost" car, in which was fitted a six-cylinder in-line engine of 40/50 h.p. Rolls later turned from motor racing to flying, and was killed in a flying accident at Bournemouth in 1910. Royce himself became a very sick man at that time. He was able, however, to supervise the design of the famous family of Rolls-Royce aeronautical engines, the first of which, the "Eagle," developed 225 h.p. at 1800 r.p.m. when it first ran in 1915. In this series, also, were the "Falcon" and the "Condor," all having twelve liquid-cooled cylinders in vee arrangement. By 1924, 7186 of these engines had been built. They were followed by the "Kestrel," a basically similar engine which was developed to give 785 h.p. and 4750 units were built. Royce lived long enough to see design work started on the "Merlin" engine, which completed its first 100-hour run at a rating of 790 b.h.p. a few months after his death in 1933. It was to become the most renowned piston engine in the world, and 150,000 of them were produced.

## Dickinson Memorial Lecture

THE Newcomen Society for the Study of the History of Engineering and Technology has decided to institute a Dickinson Memorial Lecture to commemorate the work of the late Dr. Henry Winram Dickinson, M.I.Mech.E. Dr. Dickinson, it will be recalled, was one of the founder members of the Newcomen Society, and served as its honorary secretary for more than thirty years. He was president of the Society from 1932–34, and contributed many papers to its *Transactions*. His enthusiasm for and energy in the work of the Society continued unabated up to the time of his death, at the age of eighty-two, on February 21, 1952. The memorial lectureship has been established in collaboration with the affiliated society in North America. Lectures will be delivered at intervals of two years and will deal with topics associated with technological and scientific history in a manner likely to be appreciated by both technical and non-technical audiences. Each lecturer will receive a bronze medal. The first lecture will be given on Wednesday, May 12th, at 6 p.m., by Professor Charles Singer, whose subject is to be "The New Era in the History of Technology." The place of the lecture is the Science Museum, South Kensington, S.W.7, where, until his retirement in 1930, Dr. Dickinson was for many years keeper of the mechanical engineering collections.

## Pneumatic Tyres in Agriculture

IN 1933, the Royal Agricultural Society made a silver medal award in respect of Dunlop pneumatic land wheel equipment exhibited at the Royal Show at Derby. In that year Dunlop pneumatic tyres were first used in this country for agricultural purposes on a low-loading cart built to the design of Mr. James Gilmour and Mr. John Lockhart, who were farming in the Birmingham district. Last Monday we attended a luncheon party at Fort Dunlop to celebrate the "coming of age" of Dunlop agricultural tyres. Mr. Gilmour and Mr. Lockhart were both present, together with Mr. W. E. Hardeman, a member of the original team responsible for the early design of agricultural tyres. During the luncheon, the early applications of pneumatic tyres to agricultural purposes were recalled, as was the subsequent use of these tyres for tractors and many items of farm machinery and equipment. In 1934 the Dunlop Rubber Company, Ltd., received a second silver medal, from the Royal Agricultural Society, for "farm tractor wheels with pneumatic tyres." Prior to the luncheon last Monday, visitors had an opportunity of seeing something of the research and testing work now carried out at Fort Dunlop in connection with the manufacture of agricultural tyres. The demonstrations in the research centre included methods of abrasion testing and the effect of tread hardness on tractor tyre wear; the tensile testing of tyre textile cords; tractor tyre deflection testing; and tyre tread lug stiffness measurement.

## Rimutaka Tunnel, New Zealand

A RAILWAY tunnel 5½ miles in length which is being constructed under the Rimutaka Mountains, on the North Island of New Zealand, was holed through on April 20th, we are informed. Construction of the tunnel was started at the end of July, 1951, and the progress made up to the present has included construction of most of the concrete lining; 2000ft of the lining had still to be placed on April 1st last, and is expected to be completed in May. The tunnel is of horseshoe section 15ft by 17ft in cross section, and was driven from two portals, one at Mangaroa, which is about 25 miles from Wellington, and one at Featherston at the eastern end of the tunnel. During the early part of the work unstable material was encountered, and a pilot tunnel was first driven; the full section was braced with timbers between which reinforced concrete rings were poured. When better conditions were encountered later in the work, a maximum rate of progress of 250ft of tunnel driven and timbered in one week was achieved, with a corresponding weekly maximum of 208ft for the concrete lining. The whole length of the tunnel had to be timbered. The New Zealand Ministry of Public Works is responsible for the construction of the tunnel, which is being built by the Morrison-Knudsen Company of New Zealand, an associate of the parent American company of that name, as contractors in association with another New Zealand firm, Downer and Co., Ltd.

# OWEN FALLS DAM AND POWER STATION ON THE VICTORIA NILE, UGANDA

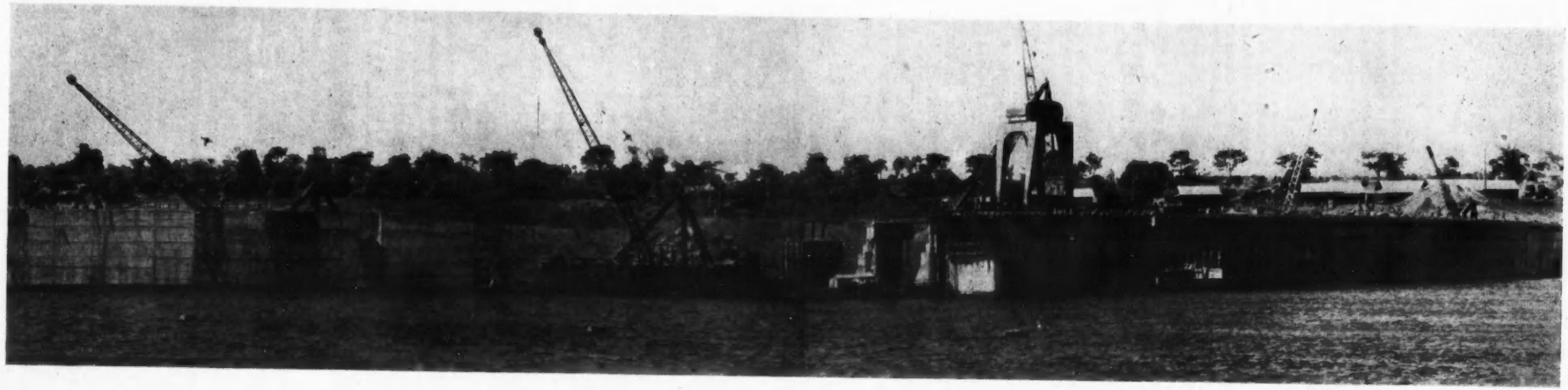

Fig. 1—Constructional Progress on the Owen Falls Dam on March 18th, Showing Dam and Reservoir

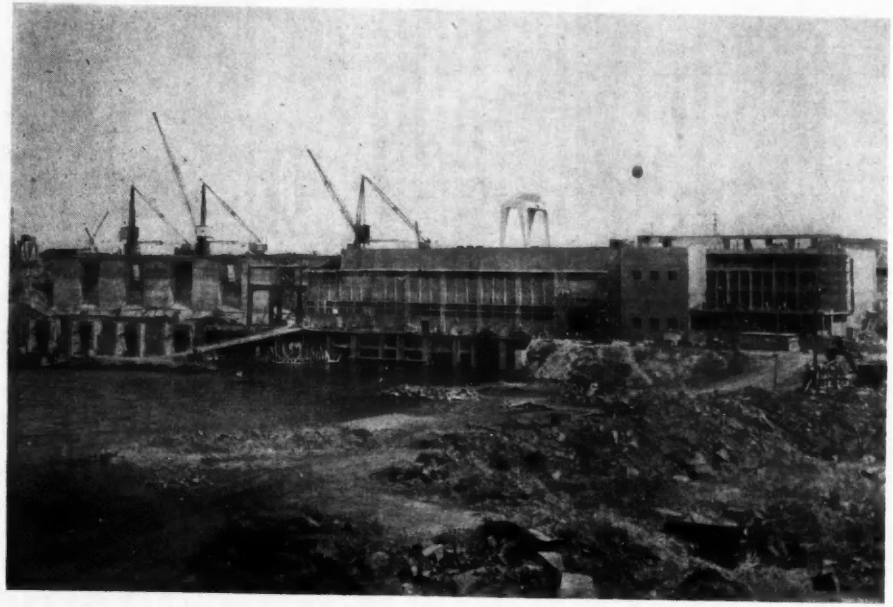

Fig. 2—Power Station and Intake Dam from Downstream

Fig. 3—Downstream Face of Main Dam

# Owen Falls Hydro-Electric Scheme

## No. I

*A major engineering development in Equatorial Africa, the Owen Falls hydro-electric scheme on the Victoria Nile in Uganda, was inaugurated by Her Majesty the Queen on Thursday last. The fundamental design and layout of the scheme are described here, together with an account of the civil engineering works.*

ON Thursday, April 29th, Her Majesty the Queen opened the Owen Falls hydro-electric scheme of the Uganda Electricity Board. The scheme is a pioneering development, which will doubtless be a major force in the development of Uganda in the near future. It consists of a dam across the Victoria Nile at Owen Falls with a power station built near the left bank next to the impounding structures. Its general layout and geographical position will be clear from the accompanying illustrations, Figs. 4–6, which show a map of the district, a plan of the scheme, and typical cross sections through the dam and the power station ; the principal data of the scheme are listed in Table I.

TABLE I—*Owen Falls Hydro-Electric Scheme*

*Dam and Reservoir*

| | |
|---|---|
| Length, feet | 2,500 |
| Maximum height, feet | 100 |
| Concrete volume, cubic yards | 230,000 |
| Volume of excavation, cubic yards | 330,000 |
| Sluice gates, six gates each | 9ft 10in wide × 16ft 9in high |
| Discharge capacity of sluice gate installation at maximum reservoir level, cusecs | 45,000 |
| Area of Lake Victoria, square miles | 26,000 |
| Natural levels in Lake Victoria : | |
| Maximum, feet above mean sea level | 3,719·5 |
| Minimum, feet above mean sea level | 3,713·5 |
| Maximum reservoir level, feet above mean sea level | 3,723·5 |
| Minimum reservoir level,* feet above mean sea level | 3,713·5 |
| Total storage available, acre-feet | $166 \times 10^6$ |
| Storage above level of 3719·5, acre-feet | $55 \times 10^6$ |
| Mean flow at Owen Falls, cusecs | 22,100 |
| Roadway over dam : | |
| Length, feet | 1,600 |
| Length of head-race bridge, feet | 570 |
| Width of carriageway, feet | 22 |
| Width of footpath, feet | 5 |

*Power Station*

| | |
|---|---|
| Length of power station building, feet | 585 |
| Initial installation, Kaplan turbo-alternator sets | 4 × 15MW |
| Ultimate installation, Kaplan turbo-alternator sets | 10 × 15MW |
| Ultimate annual production | $710 \times 10^6$kWh |
| Maximum gross head, feet | 72·5 |
| Minimum gross head, feet | 57·5 |
| Rated turbine flow, cusecs | 3,280 |
| Maximum turbine flow, cusecs | 3,600 |
| Turbine and alternator speed, r.p.m. | 150 |
| Alternators generating at | 11kV, 50 c/s, three-phase. |
| Main transformers initial installation | 4 × 16·67kVA 11/33kV |

* The lowest draw down level shown on Fig. 5 is 3711·25 ; this level corresponds to a level of 3713·5 in Lake Victoria.

The main dam is a gravity structure, with a length of 2500ft and a maximum height of 100ft. It incorporates an installation of six sluice gates, in the centre of the original river channel, which are able to discharge the largest flood flows. The power station will ultimately comprise ten 15MW Kaplan turbo-alternator sets. It is set downstream from the line of the main dam, and the intake section of the dam is built close to it, and is connected to the main dam by two short head-race dams, as Fig. 4 shows. The line of the main dam is continued in front of the power station intakes by a road bridge. The maximum gross head of the scheme is 72·5ft and its ultimate firm power output will be 135MW at 60 per cent load factor, equivalent to almost 710 million kWh annually. Existing 66kV transmission lines extend from the scheme to the west to Kampala and Entebbe, and to the east to Tororo and Mbale. Transmission between Kampala and Tororo at 132kV is planned.

The Victoria Nile at Owen Falls offered very favourable opportunities for hydro-electric exploitation. At the site selected the river channel is narrow, with a spur of rock on the left bank. The dam blocks the main channel, and the power station is built on the rock spur, the presence of which enabled the power station foundations to be built with the aid of a downstream cofferdam only. The quantity of excavation necessary to form an adequate head-race on the upstream side of the spur was small. The rock at the site is amphibolite.

The layout of the scheme, as described above, was thus determined from the configuration of the site, and its design follows generally conventional practice for a scheme of this kind. It is unusual, however, in the exceptional conditions for storage of water, due to the vast reservoir of Lake Victoria. The constructional methods employed for the temporary river works are also of technical interest. And, of course, the scheme has not been built, like European power stations, to meet an existing demand, but to encourage the growth of industry in the area, by the provision of an abundant supply of electrical power. Much preliminary work, such as the provision of camps, was necessary. The nearest seaport, Mombasa, is 800 miles away, but a metre-gauge railway was in existence close to the site. One of the modifications which the local conditions forced upon the scheme was a limitation on the size of heavy plant. For

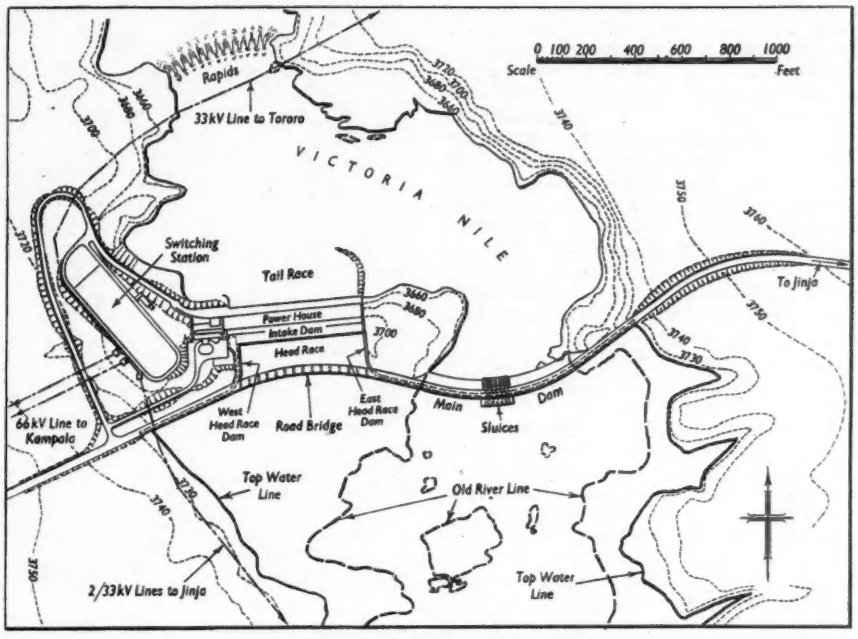


Fig. 4—Owen Falls Dam and Power Station

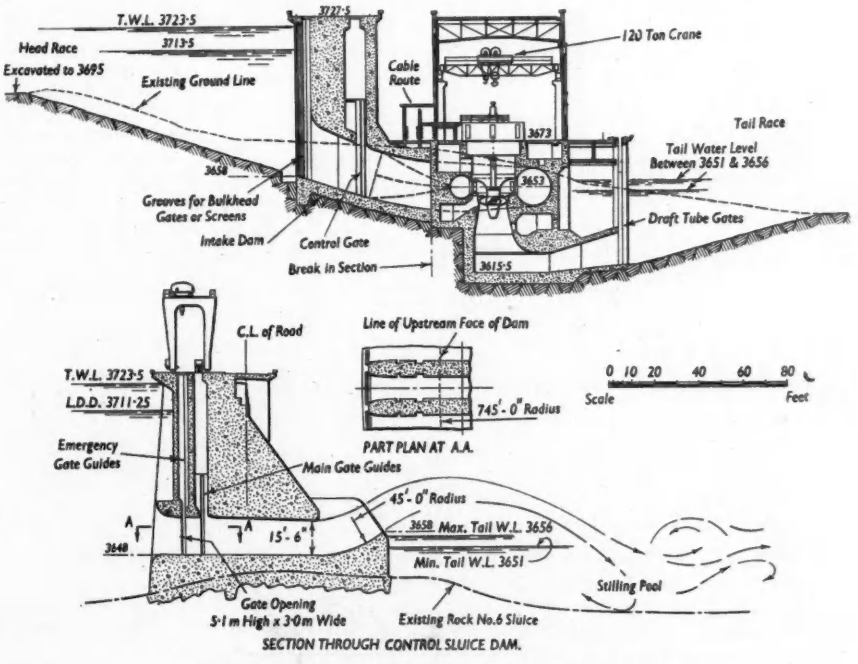


Fig. 5—Typical Cross Sections of Dam and Power Station

this reason the turbo-alternators were limited to 15MW capacity.

### Development of Electrical Load in Uganda

The main idea behind the scheme was, as we have already mentioned, to encourage the development of industry in Uganda. It was felt that the Owen Falls scheme offered an unrivalled opportunity for widening the basis of the country's economy and raising the general standard of living; an abundant power supply was essential for the establishment of industry on any considerable scale. The Protectorate has no coal or oil reserves of its own, and the sources of wood fuel are being used up ; the 800-mile railway haul of imported fuels is a serious factor in its economy. Thus the Uganda Electricity Board was formed in 1948, with the construction of the scheme as its first major objective. Other favourable sites exist further downstream, but their development is, we understand, for the future and is to be related to the general development of the country. The Owen Falls site was first considered for development in 1935 ; a report was prepared, but there was doubt about the load demand, and construction was not started at the time.

The Uganda Electricity Board has had to face various problems in establishing, from a very small start, an electricity supply industry of major importance to Uganda. The fixing of tariffs, for instance, is a complex problem. Increasing costs during the years of construction, the absence of any firm basis in a pioneer development on which to assess the growth of demand, and other factors inherent in such a novel scheme have made it very difficult to decide the long-term tariffs. During this period, and until the uncertain factors become clearer, it has been the general practice to offer electrical power at something less than the cost of any possible alternative. When the system is more fully developed, however, the Board is of the opinion that its tariffs for large industrial demands will be amongst the lowest in the world.

Over the past five years, while the scheme has been under construction, the Board has had to install alternative plant—principally diesel-driven sets—to meet the steadily rising demand. Plant totalling 15MW was ordered for this purpose, and the maximum demand has grown from 1·6MW in 1948 to 13MW at the end of last year. Nearly 9,000,000 units of electricity were sold in 1949, and about 51,000,000 in 1953. The Board therefore estimates that the Owen Falls scheme will start its life with a revenue of about £700,000 per annum. The first 90MW of plant, for which orders have already been placed, will be fully utilised, it is thought, and the Board confidently expects that the load will increase sufficiently for the scheme to be fully self-supporting financially by 1962. Already a considerable amount of work has been completed on the transmission and distribution schemes in the area, and the Board has erected during the past six years 45 miles of 66kV line, 85 miles of 33kV line, 203 miles of 11kV line, and 83 miles of low-voltage distribution. During this period the number of substations has increased from sixty-four to 269.

A word may well be said here about the organisation of the Board. It was set up under powers granted by the Uganda legislature. The chairman is Mr. C. R. Westlake and there are eight other members, including one African. The Uganda Government is represented on the Board, which is also strongly representative of local commerce and industry and has complete freedom of action in carrying out the purposes for which it was brought into being.

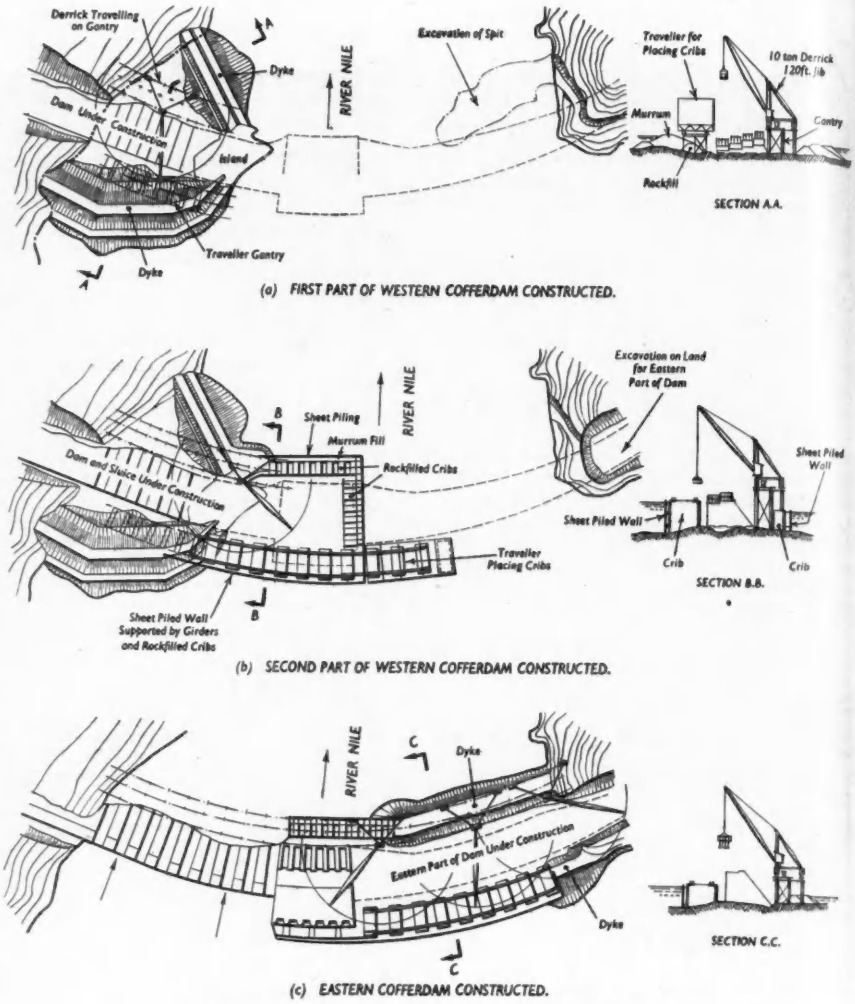


**Fig. 7—Stages in the Construction of the River Cofferdams**

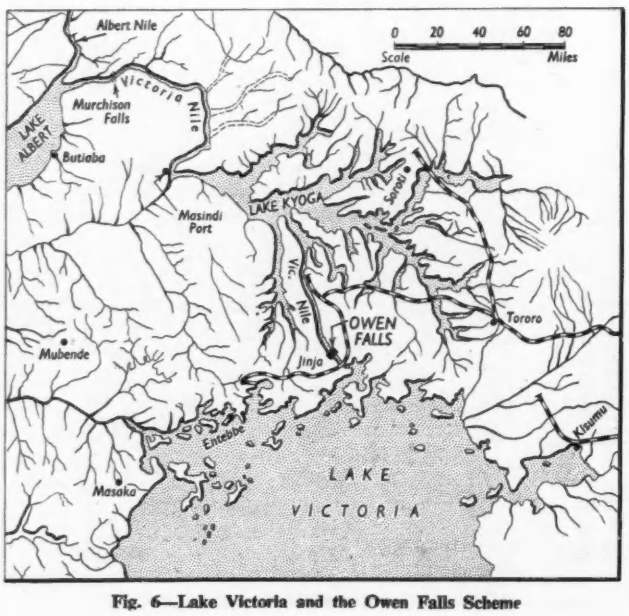


**Fig. 6—Lake Victoria and the Owen Falls Scheme**

### Hydrology and Storage

One of the great natural advantages of the Owen Falls scheme is the almost unlimited storage in the natural reservoir, Lake Victoria. The lake drains a catchment 103,000 square miles in extent, including the 26,000 square miles of the lake itself, which is 3716ft above sea level. Records of the flow of the Victoria Nile from the lake have been kept for over fifty years—again an advantage not available for the development of many rivers—and it has been established that the river flow is directly proportional to the lake level. The long-term average flow is 22,100 cusecs and the variation in flow is confined between 10,500 and 43,000 cusecs, a range of only about 4 to 1, by the regulating effect of Lake Victoria. The consultants' report of 1948, which formed the basis of the Owen Falls scheme, stated that with a storage range in Lake Victoria of 2m, a fully regulated river discharge could be obtained, giving a continuous output of 102MW.

There is, however, another factor to be considered for efficient flow regulation—that of irrigation in the lower part of the Nile valley. The flow records mentioned above were initiated by the Egyptian Ministry of Public Works, for the Victoria Nile forms an important part of the flow of the main Nile,

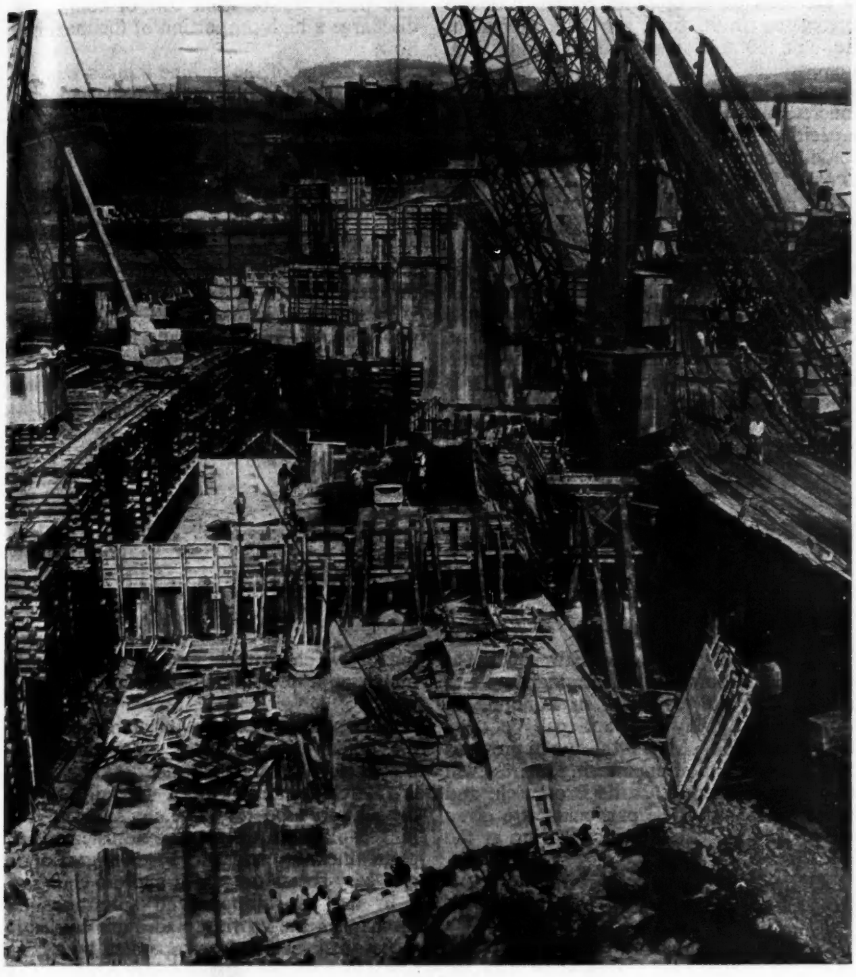

Fig. 8—Construction of Dam in Progress Inside Main Cofferdam

and control of its flow is of no little importance to successful irrigation in the Nile valley, upon which Egypt's agriculture depends. "Century" storage (i.e. storage to supplement the flow in a succession of dry years) will be provided, and the dam has been raised 1m above the level needed for the power requirements to meet this condition. That is, the maximum level of Lake Victoria is to be raised by about 1m; 55,000,000 acre-feet of storage will be added by this measure, which involves comparatively small extra cost at the dam, but probably some million pounds in compensation for lakeside land.

Thus the interests of irrigation, as in other schemes of this kind, are opposed to those of power generation, and a compromise solution has been found, in the best interests of the river development as a whole. The figures for power generation already given take account of this compromise, and a firm power output perhaps 20 per cent higher could have been obtained if irrigation demands had been neglected. The extra storage provided by heightening the dam will be built up gradually over a period of years. Much of the area which will be flooded is swamp land and it is not thought that evaporation losses will be significantly larger than at present, when the lake attains its new size. Any future hydro-electric schemes built on sites below the Owen Falls would be similarly affected by these flow regulations.

### River Works

The various stages in the construction of the main dam and its appurtenant cofferdams may best be shown by the series of diagrams in Fig. 7. Again, site conditions were favourable, for there exists a natural barrier at Ripon Falls, about 2 miles upstream, where a temporary dam, with sluices, was built. This structure partly regulates the flow in the river below it, and thus the cofferdams at the site of the permanent dam were designed to withstand a maximum flow of only 28,000 cusecs, with consequent economy in their construction. There are three islands at Ripon Falls, and the river thus flows through four natural channels, the largest of which takes about half the flow, and is situated next to the left bank. The river control works consisted first of a channel, excavated in the dry on the right bank. Four concrete piers were built in this channel, giving five openings, each of about 21ft, which could be closed by emplacing stop logs formed of steel sheet piling. When this control channel was completed, and open to the river flow, a tower 65ft high, built of timber framing with torpedo netting and rock filling, was erected on the left bank, next to the principal natural opening, and felled across the channel, by blasting. Rock fill was then added to dam the channel completely. The other three natural openings were left unobstructed, for, with Lake Victoria immediately upstream, sufficient flow regulation was thus obtained.

Construction at the main site was started on the left or western bank, by building murrum cofferdams out to a small island, to enclose the first section of the dam (Fig. 7 (*a*)); at the same time a spit of land on the opposite side of the main channel was excavated, to compensate for the restriction on the west side of the channel. The section of the dam built in this first stage was concreted in blocks 15ft wide, with gaps, also 15ft wide, left between them (Fig. 7 (*b*) and (*c*)), through which the river passed in later stages of construction.

The second stage cofferdam was built out from the island into deeper water (Fig. 7 (*b*)) so that a different method of construction was used. The cofferdam consisted of timber cribs, each about 15ft wide and about 40ft in length; each crib was placed in three sections, bolted together one above the other, with the larger dimension of the crib across the width of the cofferdam. Each section of the crib consisted of timber logs bolted together. Cribs were placed by a travelling gantry which cantilevered out from the completed work to emplace the next crib. The bottom of each crib was shaped to fit the rock configuration of the river bed; soundings were taken from the gantry at each new position and the crib shaped accordingly. The cribs were placed at 30ft centres (i.e. spaced 15ft apart) and filled with rock. Steel joists were placed horizontally across the spaces between the cribs, to support a continuous wall of steel sheet piling. The toes of the piles would not penetrate the rock and were sealed by divers with clay or concrete bag work and by grouting. Some of the rock was fissured

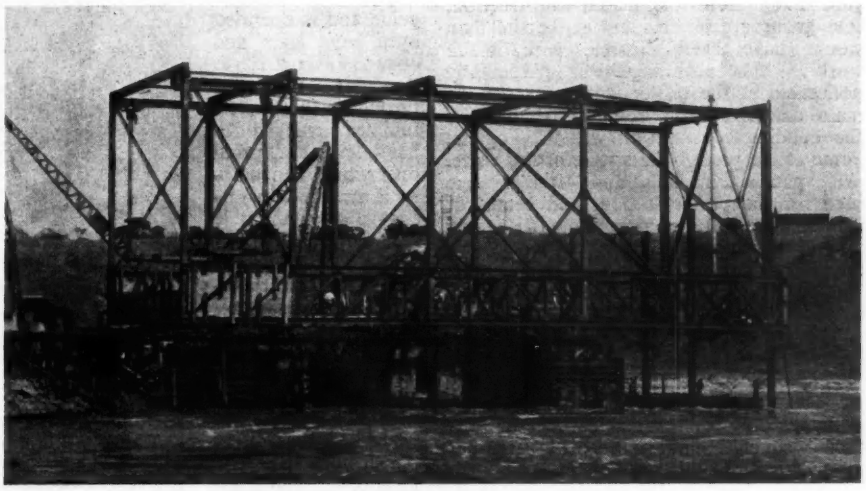

Fig. 9—Travelling Gantry for Placing Timber Cribs

and sealing of these parts of the cofferdam was difficult. As will be observed from Fig. 7 (*b*), the cribs for the side and downstream cofferdam walls were smaller, but the construction was similar. When work was completed in the western cofferdam, the river was allowed to flow through the construction gaps left on the western side and the eastern cofferdam was built, as shown in Fig. 7 (*c*). On completion of the sluices these gaps were successively closed. A wall of steel sheet piling was placed across the upstream side of each gap, supported in some cases by a curtain wall of concrete built across the upper part of the gap. Concreting was then carried out behind the cover of this wall, with grout pipes left in the construction joints for grouting the dam after the "green" concrete had fully contracted.

The rail-mounted gantry used for emplacing the cribs is shown in Fig. 9. When in use it was cantilevered out from the last completed crib, over the position of the one to be placed, and four steel joists were then lowered onto the river bed, as shown on the right of Fig. 9, where the newly placed crib may be seen in position. The cribs were lifted and handled along the gantry by four 15-ton chain blocks, shown to the left of the gantry in Fig. 9, carried on the two longitudinal joists. The maximum weight of a crib section was about 40 tons. A section of the completed cofferdam, with the permanent work in progress inside it, is shown in Fig. 8.

The maximum hydrostatic head acting on the river cofferdams was about 56ft, and the river flow reached a maximum speed of about 9 knots. As may well be imagined, construction of the cofferdams under these conditions was the most critical part of the scheme. The steel walings spanning between the cribs were welded sections 3ft 6in deep, and K.3 sheet piling was used. Around the more exposed parts of the cofferdams two lines of piling had to be driven, strutted apart, so that a diver was able to work between the two rows, sealing the gaps—gaps up to 4ft in depth were experienced—at the toe of the inner row of piles.

### Permanent Works

The dam itself is a gravity structure of conventional design. The arched shape shown in the plan is not structural and was introduced to improve the appearance of the finished work. The power station is steel-framed and is clad with precast reinforced concrete wall and roof panels. Considerable use was made of precast work. Many structural elements were cast at a casting yard away from the actual construction, thus giving greater freedom at the site than would have been possible with *in-situ* work; this advantage was particularly noticeable at the power station, where the main machinery was being installed while the building construction was in progress. Some of the precast units were of large size. Wall panels 26ft long and 4ft high were used for the power station, and beams of 38ft span, each averaging about 5 tons in weight, were precast for the road bridge and placed in position with a floating crane. The switchyard structures were also largely precast.

The concrete of the dam incorporated "plums" up to 5 tons in weight. The hearting concrete had a specified seven-day strength of 1500 lb per square inch and was made with aggregate of 3in maximum size. The facing concrete had a specified seven-day strength of 2300 lb per square inch. The aggregate plant* at the site has a capacity of 125 tons per hour of all grades of coarse aggregate, or 96 tons per hour of minus ¾in, and 60 tons per hour of sand. The aggregate is crushed amphibolite with supplementary supplies of natural sand. The concrete batching and mixing plant has a capacity of 200 tons per hour.

A number of model tests were carried out as part of the design of the scheme. The six sluice gates which, it may be noted, are low level gates giving complete control at all reservoir levels, were calibrated by tests on a hydraulic model. They have a discharge capacity of 45,000 cusecs and the maximum recorded flood is 43,000 cusecs. The small margin between these figures is, of course, very unusual in a scheme of this kind and is justified by the very complete flow records available at the site, and by the remarkable regulating effect of Lake Victoria, which precludes the possibility of a larger flood. The power station itself can, of course, also discharge a high proportion of the maximum flow.

The design of the turbine intakes was also verified by hydraulic model tests and valuable information on the river levels at different flows when the channel was restricted by the cofferdams was also obtained in the hydraulic laboratory. The tests with the sluice gates also included an investigation of the erosive action on the downstream side of the dam. As may be observed from Fig. 5, a deflector bucket was constructed on the downstream side of the sluices and the flow is deflected upwards to fall on the stilling pool some distance from the dam.

A general idea of the scale of the works at Owen Falls is given by Figs. 1–3, which are reproduced from the latest of the series of progress photographs and show several aspects of the scheme.

*(To be continued)*

* The aggregate plant at Owen Falls was described in THE ENGINEER of December 28, 1951.

# The British Industries Fair

**No. I**

THE British Industries Fair opens at Castle Bromwich, in Birmingham, and Earls Court and Olympia, in London, on Monday next, May 3rd, and will be open daily until Friday, May 14th. As in previous years the exhibits of engineering interest will mainly be centred at Castle Bromwich, and in the following article particulars are given of some of the equipment appearing at the Fair for the first time.

### Scottish Machine Tool Corporation, Ltd.

The heavy equipment exhibited by the Scottish Machine Tool Corporation, Ltd., of Govan, Glasgow, includes a combined splitting shears and punch with a bar, angle and tee bevel cropper, illustrated in Fig. 1.

The frame of this machine, which is made in four sizes, is built up from two heavy rolled steel plates, separated by distance pieces and rigidly locked together with fitted bolts. All of its motions are transmitted through a main eccentric shaft driven through vee belts by an overhead motor. The cast steel slide at the punching end is carried in a removable guide and is operated by a large lever and compression link. Punching is controlled through a hard steel tumbler arranged for hand lever and pedal operation. The tumbler is arranged to disengage when the slide reaches its top position, but provision is made for continuous punching when required. By means of a hand lever at the side the slide can be lowered on to a plate and accurately positioned when it is required to punch holes in precise locations. This slide is also balanced by a spring, the compression of which can be varied to position the punch at a predetermined height above the work.

For plate punching a hardened steel die holder is fitted to a supporting block bolted to the main frame. This support is interchangeable with a specially shaped die support used for punching sections. A hinged plate stripper can be adjusted to suit plate thickness and can be swung clear to give easy access for punch and die changing.

In the bar cropper and splitting shear mechanism the moving blades are carried in a cast steel rocking lever operated by a compression link from the eccentric shaft. This lever is spring balanced and is held in the top position when the compression link is disengaged. The control is designed for either single-stroke working or continuous cropping. The cropping blades are mounted in an accurately machined seating and are easily

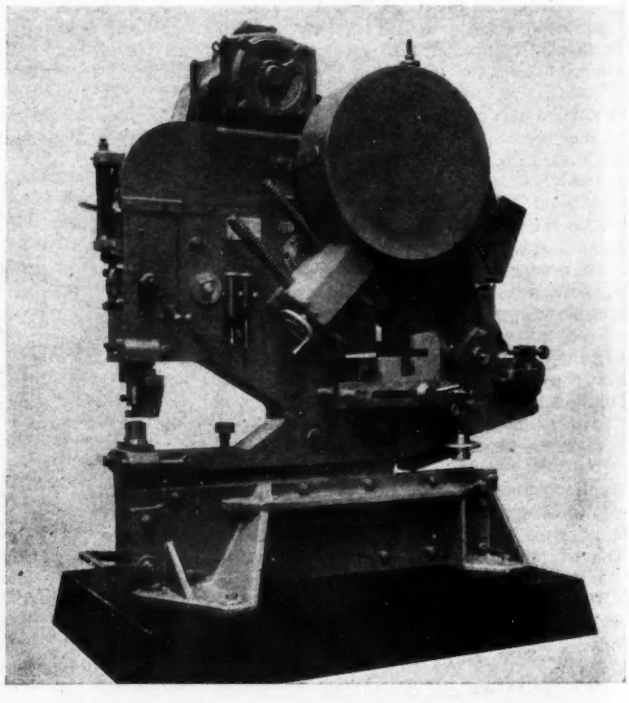

Fig. 1—Splitting Shears and Punch—Scottish Machine Tool Corporation

removable for renewal or for changing to suit different sections. For bevelling purposes gauge brackets are fitted at both the front and rear of the machine and are adjustable horizontally to give a cut from 90 deg. to 45 deg on angles or tees.

The blades of the splitting shear are parallel with the longitudinal axis of the machine and the main frame is so arranged that the plate being split passes freely right through the machine, and plates of any length or width can be split. When required, a notching device can be fitted above the plate shear for cutting rectangular notches from the edges of plates, angles, joists, or channels.

There is also exhibited on this stand a Craig and Donald 100 tons press. This press has a stroke of 8in and the width between its slides is 16½in. It is driven by a 10 h.p., 1450 r.p.m. motor and is designed to make up to forty-five strokes a minute.

### W. Kennedy, Ltd.

A portable power hacksawing machine suitable for work up to 2in square, which has been introduced by W. Kennedy, Ltd., Station Works, West Drayton, is illustrated in Fig. 2. This machine is suitable for bench mounting, and as it weighs only 40 lb can be readily transported from job to job. It is driven by a ½ h.p., 240V, 50 c/s motor.

The body of this saw is an aluminium die casting fitted with phosphor-bronze bearings which carry a hardened and ground crankshaft. The saw frame, sawing arm and vice slide are built up from bright steel hexagon bars; pressure upon a spring-loaded knob on the frame lowers the saw on to the workpiece. Saw pressure is controlled by an adjustable dashpot and spring mechanism giving a variable range of feed. Although "Platt" twenty-four teeth per inch high-speed saw blades are fitted as a standard to the machine, any type of high-speed blade up to ½in wide can be used. The blades are fixed by clamps and these clamps are such that broken lengths of blade of 6in. or more can be used.

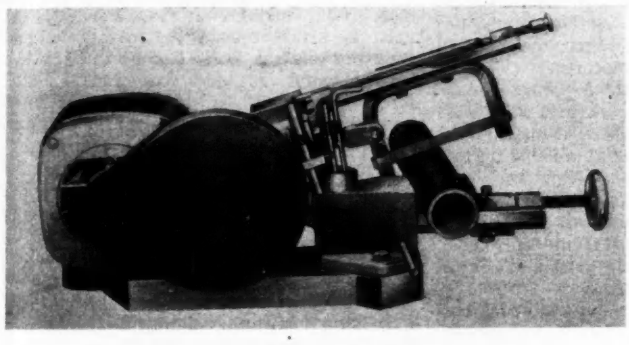

Fig. 2—Small Power Hacksawing Machine—Kennedy

### Conveyancer Fork Trucks, Ltd.

The group of fork lift trucks exhibited by Conveyancer Fork Trucks, Ltd., Liverpool Road, Warrington, includes a new arrangement of the firm's model "E2–20" machine, illustrated in Fig. 3. The new machine has a lifting capacity of 2000 lb at 20in load centre and is fitted with a 9ft lifting mast. It is designed for full free lift which enables a load to be raised without extension of the mast.

In this battery-powered machine the two front wheels rotate independently, and driving and steering are effected through a single rear wheel. The 36V battery drives a 2¼ h.p. traction motor mounted vertically over the rear wheel and a 3¾ h.p. gear pump for the low-pressure hydraulic system. The truck can be driven at speeds up to 4¼ m.p.h. when unladen and climbs gradients of 1 in 10. The steering wheel can be turned through 180 deg. when the truck is stationary, and when the machine is fitted with 30in forks it has an outer turning radius of 60in.

Fig. 3—2000 lb Fork Lift Truck—Conveyancer

Mast tilting movements are effected by a double-acting jack and a single-acting jack used for lifting gives a fork speed of 27ft per minute. When the control levers for the hydraulically actuated movements are placed in neutral the pump motor automatically stops. The driving mechanism has four speed steps to maximum power, both in forward and reverse, and is operated through a single pedal and reversing lever.

### Pollard Bearings, Ltd.

The arrangement of a new design of clutch withdrawal bearing for motor vehicles, which has been introduced by Pollard Bearings, Ltd., Ferrybridge, Knottingley, Yorks, is to be seen in Fig. 4. In these angular contact bearings the outer race is provided with an integral deep face for contact with clutch operating fingers. A steel shroud which totally seals the bearing prevents the ingress of foreign matter and returns lubricant to assist in more efficient running. The track form is so designed that the bearing is non-separable, and when the thrust load is released the balls remain within the track. By this arrangement centrifugal action has no effect on the balls and the bearing is quiet in operation.

A new series of water pump spindle bearings made by this firm is intended to simplify the mounting of automobile fans and pumps by combining in one assembly the shaft and bearing outer race. In these units the inner tracks of the two ball races are formed on the spindle itself, which is in turn accurately ground for its entire length. This makes possible a bearing having a considerably less outside diameter and eliminates the necessity for inner races. To each end of the outer race is fitted a bearing seal, which gives a rubbing contact on the spindle diameter. These seals prevent the ingress of foreign matter and at the same time the egress of grease from the bearing. When the bearing is initially fitted it is charged with a supply of lubricant, which is stated to be sufficient for the entire life of the bearing, thus eliminating any necessity for a grease nipple.

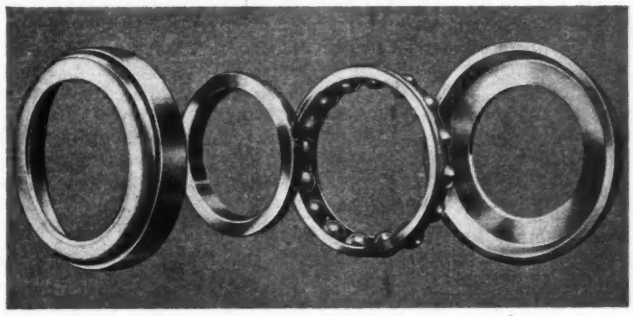

Fig. 4—Arrangement of Clutch Withdrawal Bearing—Pollard

### Keith Blackman, Ltd.

The large number of fans to be shown at Castle Bromwich by Keith Blackman, Ltd., Mill Mead Road, London, N.17, gives a good impression of the many industrial and marine applications for which this firm builds fans.

One of the new products to be displayed will be a "Tornado" 33in trunnion-mounted axial fan for marine use. This fan has a cast impeller with aluminium-silicon alloy blades of true aerofoil section, which is directly driven by a 1340 r.p.m., 5·6 h.p., compound wound direct current motor, trunnion mounted on brackets inside the case. In order to give a high degree of accessibility to the motor and impeller two large quick-release doors are fitted in the casing. Through these doors both the motor and impeller can be withdrawn for maintenance and overhaul, and if necessary replaced by spares so that the ventilating system can be restored with a minimum of delay. The simple design of the trunnion mounting and the ease with which the electrical and lubricating connections can be made simplifies such a change

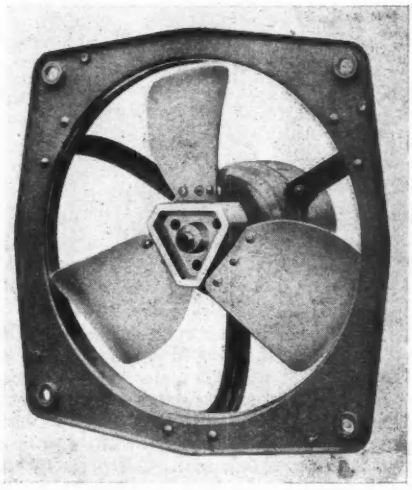

Fig. 5—Propeller Axial Fan—Keith Blackman

over of components in a ventilating system. Alternatively the system can operate on the natural draught principle with the fan doors closed, there being negligible interference to the natural passage of air when the motor and impeller are not fitted.

The motor bearings may be conveniently lubricated even while the fan is in operation, as the lubrication tubes are extended to the outside of the fan case.

In Fig. 5 we illustrate a recently introduced ring-mounted, propeller-axial fan, designed to give quiet operation under free air or light resistance conditions. The impeller of this fan has only three blades, which are mounted on the fillets of a cast hub. Each one-piece pressed steel blade is curved to give strength and rigidity, and no form of swaging or external stiffening is required.

The unit to be exhibited is one of a range of standard fans up to 48in diameter. These fans are 70 per cent reversible, which means that when running in reverse they give 70 per cent volume and take 70 per cent power as compared with the normal direction of rotation. Normally the fans are arranged for direct drive by any form of electric motor, but, if required, they can be supplied for indirect vee rope pulley drive. The fans can be supplied with the steel impellers galvanised or otherwise protectively finished to suit particular conditions, and weatherproof motors can be fitted. If required, the impeller blades can be made from brass, aluminium or plastic materials.

The fan can be installed at any angle as its impeller is mounted on substantial ball bearings and accurately aligned and balanced. Provision is made for the drainage of water from the impeller hub, where it might otherwise accumulate, should the fan be mounted out-of-doors with its axis vertical.

### Steeloid, Ltd.

In a number of small factories and industrial establishments the quantity and weight of goods to be moved from place to place do not always justify the cost of a power operated truck. For this reason the simple pedal truck illustrated in Fig. 6 has been introduced by Steeloid, Ltd., 2, Ridley Place, Newcastle upon Tyne, 1.

This two-wheeled truck consists of a platform 2ft 10in wide by 7ft 4in long

**Fig. 6—5-cwt Capacity Pedal Operated Truck —Steeloid**

which takes goods weighing up to 5 cwt. Coupled to the rear of the truck by a hinge-pin is a pedal drive unit with a spring-mounted operator's seat. All parts of the truck are strongly built in sheet steel and standard cycle components are used in the propelling mechanism.

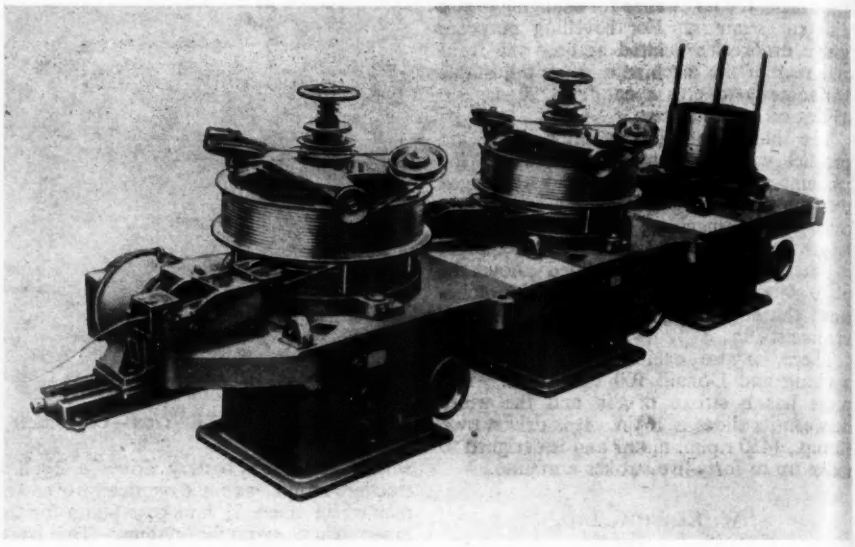

**Fig. 7—Concentric Differential Block Non-Slip Wire-drawing Machine—Farmer Norton**

### Sir James Farmer Norton and Co., Ltd.

A new concentric differential block, non-slip, wire-drawing machine is to be shown this year by Sir James Farmer Norton and Co., Ltd., Adelphi Ironworks, Salford, 3. This machine, of non-slip, unit construction, is designed for high production speeds and straight line drawing, and it is illustrated in Fig. 7. One of the particular advantages in operation of the machine is the elimination of twist in the wires between the blocks, which are driven by a.c. motors.

A new finishing block or single holer exhibited is designed to increase efficiency and enable the production on a machine of weights of finished coils unobtainable on the firm's standard machines. One of these single or finishing blocks can be stripped in a few seconds and this makes it possible to increase the efficiency of a multiple hole machine by some 10 per cent and single blocks by some 40 per cent.

Two of the firm's rotary swaging machines are to be shown, one of the rotary spindle, two-die design, and the other an inverted stationary spindle, four-die machine. The two-die machine is suitable for bar and rod up to 1in diameter. The other machine has proved particularly suitable for tube swaging and can also be used for reducing the ends of such sections as flats, squares, hexagons, &c. Both machines are fitted with pneumatically controlled silencing devices, which in addition to reducing noise, also prevent wear and tear of the machines.

An associated firm, Wire Drawing Dies (Manchester), Ltd., will show shaped dies with new profiles which enable bright drawn finished bar to be produced from black bar stock in one pass.

### Lansing Bagnall, Ltd.

The new equipment to be exhibited upon the stand of Lansing Bagnall, Ltd., of Basingstoke, Hampshire, includes a diesel-engined fork truck with a capacity of 1 ton at 20in centres and a lift of 10ft 10in. This truck is driven by an air cooled, twin cylinder Enfield engine, and has a maximum speed of 8–10 m.p.h. The power unit is designed to give easy access to the clutch assembly, which, if necessary, can be changed in a few minutes. Drive is transmitted through the front wheels and steering is effected through the rear wheels of the truck.

Another new machine to be shown is a stand-on, battery, straddle fork truck with 30in forks designed to lift up to 2500 lb to a height of 10ft 10in. This machine has a special pivoting system which ensures that all four wheels remain in contact with the ground on uneven surfaces. It has a maximum speed of 4½ m.p.h. and is fitted with regenerative braking.

A number of the trucks on show, like that illustrated in Fig. 8, will have the new fixed mast tilting carriage. In these machines the mast is firmly braced to provide a rigid structure and the forks can be tilted 3 deg. forward and 10 deg. backward. Each track is fitted with a tilt indicator actuated by simple mechanical links from the carriage.

Power for lifting and tilting the carriage is provided by a high pressure hydraulic pump driven by an electric motor. A solenoid switch operates the motor from contacts on the hydraulic control valve.

A single large capacity extending jack is used for mast elevation and a system of chain linkage provides a free lift without increasing the overall height. Twin hydraulic rams ensure smooth tilting of the carriage, which is pivoted near its upper edge so that on tilting with a load the movement of the

**Fig. 8—Fixed Mast Tilting Carriage Truck— Lansing Bagnall**

centre of gravity of the load is almost vertical.

All lift and tilt movements of the machine are smoothly controlled by the operating lever and the maximum speeds of lowering and forward tilt are automatically controlled

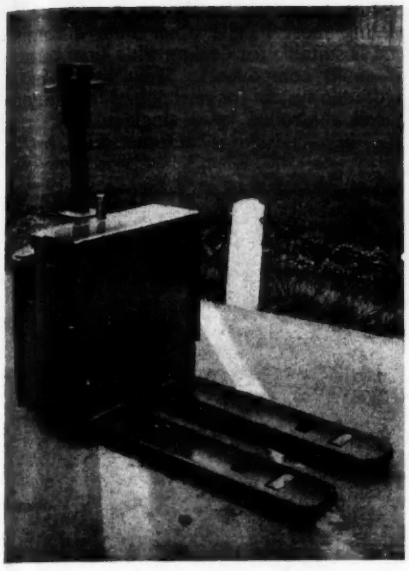

Fig. 9—Pedestrian Controlled Battery Pallet Truck—Lansing Bagnall

by a flow valve. A pressure relief valve is incorporated to prevent overload.

The pedestrian controlled battery-electric pallet truck illustrated in Fig. 9 has a capacity for hauling loads up to 3000 lb and is fitted with 36in forks. This machine is fitted with a built-in charger, but if required the batteries can be changed to permit continuous operation.

The single front wheel which is used for steering forms part of the complete drive unit incorporating the handle, motor and drive gear. The speed control fitted in the handle head consists of two press-buttons controlling forward and reverse movements. Five speeds, up to 4 m.p.h., can be selected by varying the pressure on these press-buttons. A regenerative braking system can be used to limit the speed of the truck when descending inclines, without recourse to the mechanical brake which can be applied with the control handle either in the horizontal or vertical position.

### Bristol Aeroplane Company

A permanent aluminium building—a "Mark III" two-class-room school—designed for use in tropical and subtropical areas, forms part of the exhibit of The Bristol Aeroplane Company, Ltd., at Earls Court. Also shown is a large "Mark IA" building, comprising a reception lounge adjoined by a complete hospital operating suite. The "Mark III" building is the latest development of the "Bristol" system of aluminium unit construction and is being shown for the first time. The "Mark IA" building is typical of the current products of this system, which has been in use for nearly six years.

The "Mark III" system of construction has been developed as a direct result of a sales survey of the African market carried out by the company's sales manager. Special attention has been paid to proofing against vermin and termites and the company states that it has given particular attention to transport problems to minimise transport costs. The exterior skinning of the aluminium roof and walls of "Mark III" buildings are given a grey matt finish by chemical treatment. An airflow through the roof space is ensured by ventilation openings at the eaves and at the base of the barrel vault on both sides. Ceilings of ribbed aluminium sheet, also with a grey matt finish, are provided, with a glass wool blanket overlaid to give thermal and acoustic insulation.

The inner lining of the walls, which have a horizontally ribbed outer skin, is of a non-combustible wall board made from asbestos fibre and diatomaceous earth, proof against vermin, rot and extreme humidity. Between the outer and inner skins is a glass wool blanket 1½in thick, which gives the solid wall a thermal insulation value equal to that of an 11in cavity brick wall. Side walls have sliding windows and adjustable aluminium louvres, the windows being arranged so that two-thirds of the glazed area on each side of the building can be opened, thus ensuring cross ventilation. Internal partitions are made from wood wool slabs surfaced on both sides with vermiculite plaster or similar material and provide adequate acoustic insulation between rooms. The frames of the windows and doors are of aluminium; doors have aluminium-skinned solid portions and glazed panels of ¼in Georgian wired polished plate. The buildings are designed to stand wind velocities of 65 m.p.h. During erection all joints are made by bolting or screwing.

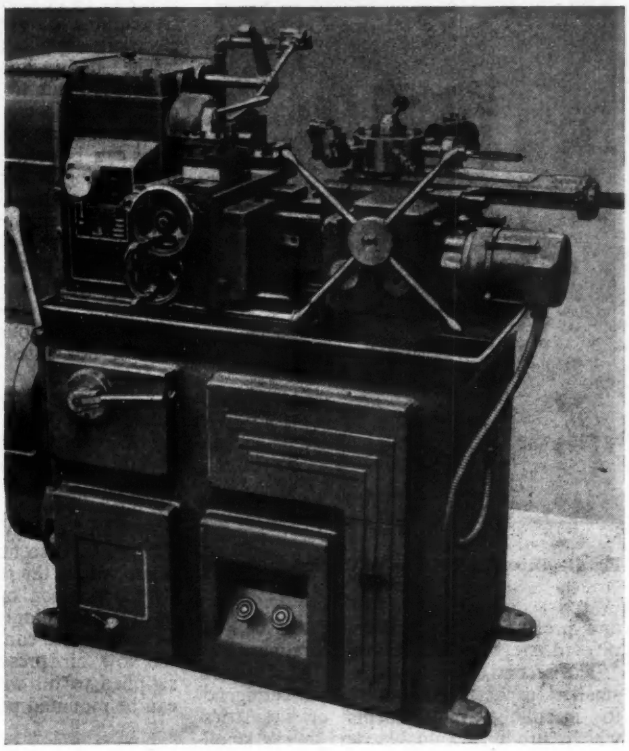

Fig. 10—One Inch Capacity High Speed Capstan Lathe—Murad

### Murad Developments, Ltd.

Amongst the very small number of machine tools to be seen at the Fair will be a group of high-speed capstan lathes and grinding machines exhibited by Murad Developments, Ltd., Stocklake, Aylesbury, Bucks. One of these capstan lathes, the firm's model "1B," is illustrated in Fig. 10.

This lathe has a 1in capacity and its centre height of 5½in gives a swing of 11½in diameter over the bed, and 6in over the cross slide. Work up to 16in long can be admitted between the front of the collet cap and the turret, which has a maximum useful stroke of 4½in. The flanged spindle is bored 1 7/16in diameter and can be fitted with a 6in capacity chuck or fixtures for irregular-shaped workpieces. It is driven through a two-speed gearbox and a two-speed motor through stepped pulleys, which gives a range of sixteen spindle speeds from 62 r.p.m. to 1800 r.p.m. The final drive to the spindle is transmitted by two vee ropes tensioned by a jockey pulley mounted on an eccentric stub shaft. A spindle brake is fitted and is applied when the operator presses the control lever through which the drive ratio is selected.

The turret is actuated by a separate motor drive through gears and a spring-loaded safety clutch and it has six feed rates from 0·34in to 10·8in per minute. The drive is engaged by a drop worm mechanism, which is automatically disengaged at the end of a cut by the turret stop screw or by the operator moving a quick-release lever. There is also a hand-operated turret slide movement.

The cross slide has a movement of 7in along the lathe bed and a transverse movement of 4½in, and it can be fitted with back and front tool posts. An auxiliary back post slide has a maximum adjustment of ⅜in.

The double-ended pedestal grinders made by this firm for 8in and 16in wheels have built-in dust arresters. At each side of the rotor of the centrally placed motor on this design of machine an impeller is fixed to the spindle. These impellers draw air from the hoods enclosing the wheels and down through dust filters in the legs of the machine. The cleaned air, after cooling the motor, is exhausted into the atmosphere. The dust removed from the air by the filters drops into a tray at the foot of the machine, whence it can be easily removed.

### Roto-Finish, Ltd.

The equipment to be exhibited by Roto-Finish, Ltd., 39, Park Street, London, W.1, for deburring, polishing, radiusing, &c., of parts includes two recently introduced machines primarily intended for handling small batches of precision components.

One of these machines has a barrel 32in in diameter by 12in wide, and takes 30 lb to 50 lb of precision components, together with the processing chips and compounds in solution. It was designed from a machine originally used for laboratory testing and is equipped with all the features on the firm's larger standard machines. Means are provided for gentle inching control of the barrel for loading and unloading. It has a perforated washout drawer for cleaning components

Fig. 11—Deburring, Polishing and Radiusing Machine —Roto Finish

and processing chips, and is fitted with a pivoted safety guard and a process timer.

The second new machine (Fig. 11) is of smaller capacity and has been designed to meet the requirements of industries which produce valuable and very small components, such as for watches and instruments. It is fitted with a system of overlapping chutes to prevent the loss or damage of minute or valuable parts during separation from the chip mass after the completion of the deburring or fine polishing run. In order to facilitate the rapid change over of components and provide storage for alternative grades of chips, two reserve loading pans are provided at the base of the machine.

### Monometer Manufacturing Company, Ltd.

A new design of hydraulically operated "lip-axis," crucible melting furnace, introduced by the Monometer Manufacturing Company, Ltd., 115–116, Strand, London, W.C.2, is to be exhibited. The maker points out that its previous furnaces of this type have had the hydraulic equipment mounted in a pit beneath the furnace. This makes the installation of the furnace expensive and the pits are a nuisance because they collect metal spillage, dirt and water, and maintenance is difficult.

This new furnace is designed to eliminate these troubles and is supplied in one unit ready to be dropped on to foundation bolts. It requires only to connect air, oil and electricity supplies to complete its installation.

The body, lined with "Lumen" fire-bricks, is made to take the standard sizes of crucibles, or it can be fitted with a cast iron pot for melting zinc-base metals.

As can be seen from the drawing Fig. 12, the pivoting and lifting trunnions are fitted each side of the body. The pivoting trunnions fit in plummer blocks mounted on totally enclosed side frames, in which are enclosed the clevis-mounted hydraulic rams. The top of these rams are secured to the lifting trunnions and the rest of the hydraulic equipment is housed in a totally enclosed control box fitted outside one of the side frames.

Movement of the body is controlled by a single lever with a three-positional spring centred control. The central or neutral position of the lever allows the body to lock in any position while the in and out positions control raising and lowering. Movement continues only whilst the lever is held in position, and the rate of ascent can be regulated at the pump, whilst the rate of descent is controlled by the position of the lever, and the rams have end cushioning to prevent jarring.

The furnace can be fired by oil or gas and the low air pressure burner used can be supplied to tilt with the furnace body or it can be mounted permanently on the ground.

### W. Canning and Co., Ltd.

Exhibits on the two stands to be occupied by W. Canning and Co., Ltd., Great Hampton Street, Birmingham, 18, are designed to give a general impression of the most recent developments in the electro-plating, polishing and allied sections of the metal and plastics finishing industries.

The largest exhibit will be a 35ft long hydraulic-electric, single-process automatic plating plant, complete with ancillary equipment, including rectifiers, transformer, voltage regulator, filter, &c. If required large automatic plants of this type can be supplied incorporating multiple processes—such as copper, nickel and chrome plating in a combined installation. In this plant the operations of lifting and transferring the plating racks from one tank to another is carried out by the hydraulic system and the whole conveyor is operated as a single unit. Either steam or electric heating can be used and exhaust ducting can be supplied where necessary with either overhead or underground discharge.

Control of the entire plant is maintained from a cabinet mounted near the loading and unloading station in a position convenient for the operator.

A new design of the firm's open-mouthed plating barrel to be shown is suitable for plating most metals other than chromium and is suitable for dealing with large outputs of small components. This barrel has a hydraulic system for raising and lowering the barrel controlled by a single master lever. The barrel drive is automatically broken when the lever is depressed to raise the barrel from the tank and re-engages when the barrel is lowered into the solution. The barrel has an article capacity of 3 gallons and rotates at approximately 10 r.p.m.

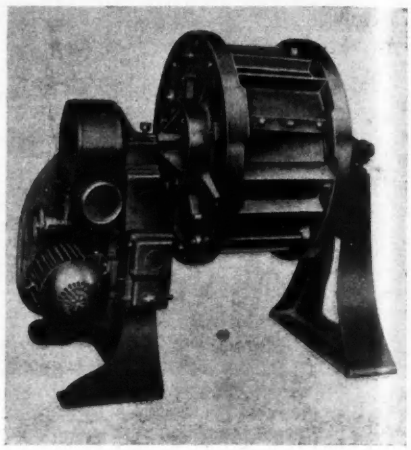

Fig. 13—Rotary Finishing Barrel—Canning

The "Tynee" filter unit which will be exhibited is suitable for continuous filtration of most plating solutions other than chrome. It is intended for use with tanks up to 300 gallons capacity and can be supplied as a static unit or mounted on a lightweight tubular chassis with wheels. Essentially, the unit comprises a motor-driven pump which is housed under a rubber-lined container. This container holds the filter pack which is easily removable for cleaning and inspection.

The "Gallay" junior rotary finishing barrel, shown in Fig. 13, is used for deburring, scouring or burnishing small components in bulk. It is wood lined, fitted with a watertight lid and has a work capacity of 4 to 5 gallons. Drive is by a 2 h.p. motor through worm gears and vee belt, and the barrel speed is variable between 18 to 40 r.p.m. under the control of a hand regulator wheel. A hand-wheel is fitted for inching to assist in positioning the barrel for loading and unloading. The "Gallay" process utilises special pebbles and compounds to suit various types of articles and it is suitable for scouring and burnishing steel, brass, aluminium, zinc alloys, and components made of other materials.

*(To be continued)*

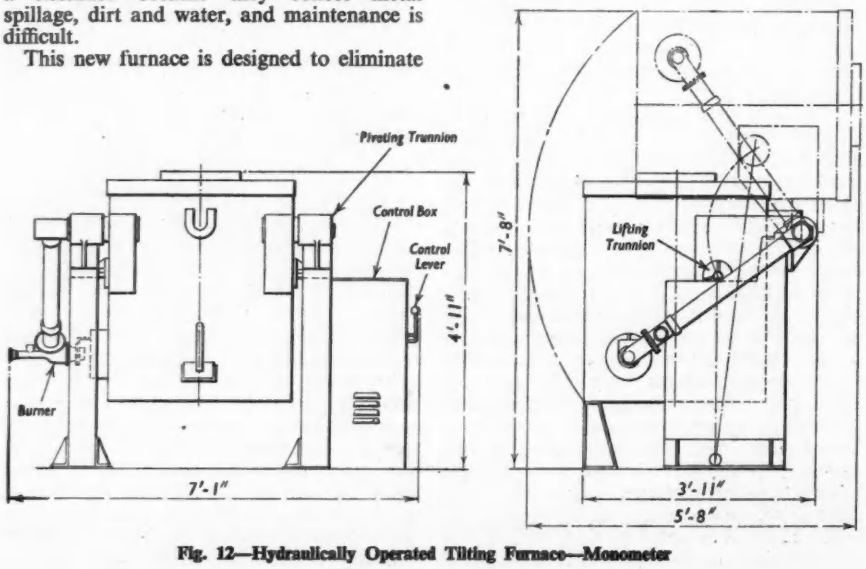


Fig. 12—Hydraulically Operated Tilting Furnace—Monometer

Oil Facilities in West Africa.—The Shell Petroleum Company, Ltd., is expanding its oil supply service to shipping and inland users in West Africa. A new bunkering installation consisting of four tanks, each of 15,000 tons capacity, is being built on 10 acres of reclaimed land at Dakar, with provision for two more tanks of the same size and, in addition, there will be three bitumen tanks with a total capacity of 9000 tons. Oil tankers up to 18,000 tons deadweight can discharge at the new installation. At Apapa, in Nigeria, fourteen tanks for the stowage of petroleum products are being built.

# Air Pollution Control

## INSTITUTION OF MECHANICAL ENGINEERS

THE James Clayton paper, "A New Frontier: Air Pollution Control," by Frederick S. Mallette, M.A.S.M.E., was delivered at a general meeting of the Institution of Mechanical Engineers in London on Friday, April 23, 1954. At the beginning of the meeting the chair was occupied by Dr. R. W. Bailey, D.Sc. (Eng.), Wh.Sc., F.R.S. (President), and later by Mr. Crowe.

### Discussion

Sir Ernest Smith, C.B.E., D.Sc (London): The Smoke Abatement Society, of which I am the President, appreciates very much the compliment that you have paid me in asking me to open the discussion. The Americans are particularly fortunate in having a "Mallette" with which to drive this question home. We appreciate very much that he has come to help us to drive our own difficulties home. He will find that the Smoke Abatement Society has existed for very many years—since 1925 and before—but, in spite of all its propaganda—all that it exists for is propaganda and education—until recently it has not achieved anything like sufficient success. During the last ten or fifteen years, and particularly since the smog trouble, it has been remarkable to see the way in which industry has taken this matter seriously. The D.S.I.R. for years has been carrying out a great deal of research work in conjunction with local authorities, and a great deal of information is available for those who take this subject seriously.

I hope that the author will at some time give another paper in which he will link fuel efficiency with anti-smoke troubles. As you know, we in this country have linked those two subjects together, and we contend that the main trouble giving rise to smoke, whether from coal or from oil, is wasteful combustion, of which the smoke is an indication. Stress has very largely been laid on the steel industry in the paper. I should not like it to be thought at this meeting that the steel industry of this country is one of the major delinquents. I know from our own experience and information that a great deal of money has been spent in the steel industry to eliminate as far as is practicable—after all, we are not a rich country to-day—the nuisances that used to be caused by the steel industry, and still greater strides are being made and will be made in the future.

My view is that the new organisation, the National Industrial Fuel Efficiency Service, is one which should be supported and backed sympathetically in the belief that enormous strides by industry are possible. Unless that body, with its finances, which are quite inadequate, is backed, it will get nowhere.

The paper lays stress on $SO_2$ and on petrol fumes. I do not think that it lays enough stress on badly managed diesel engines, whether they be in motor-buses or motor-cars. I believe that there will have to be regulations—Government regulations, if necessary—indicating how a diesel engine should be used for motor transport. Even our most advanced motor-buses are not, to my mind, giving the satisfaction that they should give; and the poison which is put into the atmosphere from diesel engines, and even from motor-cars, which are badly regulated is serious. We also very definitely need to have legislation to limit the amount of smoke which steamers and other ships on the river give out on London.

Dr. R. Lessing (London): Those of us who attended the Air Pollution Conference in Washington in 1950 were struck by the enormous attention that was given to the pollution problem in the North American Continent, both in the United States and in Canada. When we hear a paper about what the American conditions are, we have to remember that our conditions in this country are very different indeed. In the first instance, we are a small country and pollutants do not disperse and become innocuous in wide open spaces as they do on the American Continent. We have also to consider our coal supply, which is, after all, the main contributor to pollution, and it is a very different one from that in America. First of all, we have not the choice, not even by Nature, of selecting coals according to our liking, and we have not the opportunity of doing what the Americans do in distinguishing between their low volatility coals, of which they have plenty, and their soft coals of the Middle West, which can be used under suitable conditions with relatively little trouble in industrial installations. That is quite apart from the fact that we have not got a "political" choice; we are unable to pick out what the National Coal Board shall supply to us.

The principal pollutant is smoke. This has been diminishing over the last forty years. But it has not yet disappeared. Other facilities for domestic heating by gas and electricity have been provided, and, after all, we have improved some of our 12,000,000 domestic hearths.

In connection with grit, it must be said that, while smoke is a problem of proper and efficient combustion of the volatile matters, the grit nuisance is largely due to the natural dust which is present in coal. It amounts in this country to a total of about 10,000,000, and where coal—I am now speaking of lump coal and not pulverised coal—is fired with forced draught or any appreciable draught that dust is the first thing which is blown out of the chimney as non-combusted or only partially combusted material. Therefore we have a menace which in quantity amounts to about 2,500,000 to 3,000,000 tons per annum over the whole country. That could be remedied if the dust were extracted at the colliery in the course of coal preparation more efficiently than it is done at present, if it is done at all. At one time it was done. The necessity now to use water underground for dust prevention purposes has made that problem a very much more difficult one.

The third matter is sulphur, to which I have referred many times before. The sulphur in our coal leads to the emission in a final form of about 9,000,000 to 10,000,000 tons of sulphuric acid. It is the sulphur which is the corroding agent which causes the actual damage. While smoke and grit, which can be swept up and cleaned up, spoil our amenities in general, it is the sulphur and the sulphur oxides which cause damage both material and animal or human, as we found in the terrible disaster in December, 1952. I pointed out in a paper submitted to the World Power Conference in 1930 that efficient cleaning of coal would get rid of a considerable amount of the sulphur and the dust and at the same time be an economic proposition on account of the raising of the usability of the ash-free and dust-free coal. Our coal production has sorely lacked facilities for a thorough removal of inorganic, incombustible and acidic constituents which cause all the trouble. We must strive to ensure that that removal is carried out in the future.

The Interim Report of the Beaver Committee has stated that the damage, which is very difficult to ascertain by means of accountants' or actuarial figures, is reliably estimated to be about £100 million to £150 million per annum. Obviously, to overcome all that trouble, even to study it and to carry out all the necessary research, and to devise the instruments—unless we get them all ready-made from America on dollar exchange—costs money. We are back to-day in the position in which Sir Edwin Chadwick found himself one hundred years ago, when he propounded his ideas on sanitation. They were laughed at. It was said that to put proper sanitation into our houses and install proper sewerage systems would be an uneconomic proposition and would bring ruin to the country. To-day we do not believe in that sort of view any more.

Mr. A. T. Holman: I wish to ask a question about one method of treating dust. It is a detailed method, but it may be of some importance. We have been experimenting with the settlement of dust, of sizes in the region of 1 micron and less, created by rock drilling and by the cleaning of castings by sonic agglomeration. For this purpose we find that by using a compressed air whistle at 13–14 kc per second we are getting a measure of success on a laboratory scale. We are proposing to place them in the cones of cyclones to secure an agglomeration of dust particles and prevent them from rising to the air discharge point. We are hopeful that this will succeed. On pages 17 and 19 of the paper, in referring to blast-furnace and steel industry control problems, the author mentions that sonic agglomeration has been found to be impracticable. I should appreciate it if the author would say why that was so, especially as I understand that at the North Thames Gas Board some experiments are contemplated shortly on smoke precipitation by sonic and ultra-sonic whistles because of difficulties with other methods and also their high cost.

Dr. O. G. Sutton, C.B.E., F.R.S.: It seems to me that in a country like ours we must face the situation that with the increasing manufacture of chemicals and so on some effluent is bound to get into the air. That raises the question of how you are to get rid of it. Both from theoretical and from other studies we think that it is the height of the chimney that matters as much as anything else. I should like to ask the author if there is any legislation in the United States which regulates the height of the chimney, and, in particular, whether when new factories are planned any attempt is made to look at the meteorological topography of the district, namely, whether there are any of these uncomfortable down draughts and eddies which are likely to bring the pollution down to breathing level. I should also like to know whether or not any legislation is contemplated which would make that a necessary factor to be considered when new factories are planned. The sort of thing that I have in mind is that if we know something about the meteorology of a district we can say that a chimney of a certain height giving out so many pounds per minute will produce a concentration of a certain quantity downwind.

I should also like to know whether any permissible limits are laid down for concentrations of noxious gases quite apart from those which are well known in industrial practice. I believe that 10 parts per million is reckoned to be a tolerance figure for sulphur dioxide. In the London smog the highest figure measured was just over 1 part

per million, and yet quite a number of people died.

Dr. G. E. Foxwell (London): You all know that the Air Pollution Committee was appointed rather less than a year ago and that it has issued one report. As I am a member of that Committee it would be improper for me to express any views which might be construed as a foresight of our next report. In fact, we have not decided on any views.

Let me make our position clear. We are firmly convinced that it is time that we made a concerted attack upon the pollution in the air that we breathe. That we are determined to do. We have to consider what are the appropriate ways and means. We need the backing of public opinion, and we hope that this Institution will help us to obtain that. We are more inclined to the kid-glove approach than the Americans are. Let me illustrate that from the paper.

The author has referred to the pollution from Bessemer converters. This was overcome by prohibiting owners of these plants from emitting "such quantities of soot, cinders, noxious acids, fumes or gases in such place or manner as to cause injury, detriment or nuisance to any person or the public." That was pretty comprehensive. The success that followed that measure is gauged by the fact that "there are now no Bessemer converters in the city of Pittsburgh and only three within the county." While we are mindful of the value of such an ordinance, in this country we cannot close down or remove our industries in this way, nor can we cause them to incur heavy and perhaps crippling additional costs. We must at all costs maintain our industries in being and be careful not to impair their competitive position. We are mindful, of course, of the fact that smoke abolition and efficiency go hand in hand and that very often the additional costs involved will be more than offset by the economies secured.

The author has mentioned that in Allegheny County domestic hand-fired heating plants were not required to conform to the special solid fuel requirements till June, 1953, and he records "When the heating season began there was some organised opposition on the part of the domestic users. . . The county supervisors refused any further period of grace, and there is no present evidence of extensive resistance to compliance." I should like to know more about this. How was the opposition overcome? In view of what happened to the Bessemer converters, are the objectors no longer resident in the district? Could it be that they are all in gaol?

What is it that we are supposed to be attacking? Air pollution is far wider than smoke abatement. What is the relative importance of brown smoke, black smoke, inorganic solids, $SO_2$ and $SO_3$? The paper clearly shows that no one yet knows what is the harmful constituent of smog, and I can confirm that finding. Is it, as was thought at Donora, the adsorption of irritant gases on solid particles? Is it, as Harvard suggests, some peculiar effect of $SO_2$ plus $SO_3$, not experienced in the presence of the one gas without the other? There is evidence that corrosion from $SO_2$ is increased considerably in the presence of solids. We really do not know what it is that causes injury. People can work in an atmosphere of $SO_2$—I have seen them doing it in oil refineries, and I have done it in laboratories—which is supposed to kill anybody, and yet it has not harmed them a bit.

The Air Pollution Committee are first attacking smoke and other solids on the ground that that is the most evident source of pollution that we can attack. Industrial smoke is of two kinds. There is the smoke which is produced by incomplete combustion in boiler furnaces and other straight combustion processes. We know how to deal with that. The first thing is to train the stokers to operate the boilers and furnaces properly. As soon as we begin to say—we have done it on the Ministry of Fuel Education Committee—that we should like to train the stokers and give them an incentive for being trained, the trade unions say that they will not allow incentives because they might cause the men to leave. The trade unions are all against any incentives for training stokers. We also know that we can install mechanical stokers. I am not sure that the Government have given sufficient incentive to industry to install mechanical stokers, which save money which can be put to some other use for extra production.

Mr. G. R. Peterson, M.I.E.E. (London): Not much is said in the paper about atmospheric pollution arising from the operation of power stations. This may be because the modern power station does not contribute much to pollution. However, it is by no means a small problem for the power industry, and it may be of interest to give a few details about it. First of all, to give the scale of the thing, the power industry of this country is now approaching a coal consumption of about 40,000,000 tons per year, or 20 per cent of the total annual consumption of coal in the country. Furthermore, that coal is, by and large, the worst, the dirtiest coal with the highest ash content.

The cost of a new precipitator and arresting plant is about £3,000,000 per year, while the occasional reconstruction of old plant by installing higher chimneys or improved precipitators costs £100,000 to £150,000. These figures show the scale of expenditure involved in the United Kingdom where we are tackling the problem. Smoke, tar, soot, tarry matter and carbon monoxide are in general not serious problems in connection with a modern power station, but grit and dust are. The coal that we burn contains about 15 per cent of ash, and with the modern pulverised fuel boiler 60 to 80 per cent of the ash is presented to the stack and has to be removed by the arresting plant.

The modern electrostatic precipitator can be designed for an efficiency of 98 per cent, and some precipitators have even exceeded 99 per cent on test. Therefore most of the ash can be removed. There is, however, one difficulty. Excellent devices though they are, they are not provided with any continuous monitoring devices to indicate their performance. I should like to ask the author whether he has any information of any continuous monitoring device. Such an instrument is very badly needed. In the absence of a continuous monitoring device, a good deal of attention has been given to precipitation testing of electrostatic precipitators, and that has been greatly improved.

A good deal of work has also been done on the measurement of dust fall around power stations. It might be of interest to mention one test round a power station in open country—Little Barford power station, of medium size, which is well away from any industrial areas. It has been surrounded by seventeen dust deposition gauges spaced out in a circle on a 2-mile radius from the power station, and measurements of the dust fall have been going on for a considerable while. The average in summer is 1·3 tons per square mile, and in winter 2·5 tons per square mile. These figures are very low, and the presence of an industrial plant could not be deduced from them, which suggests that the efficiency of extraction at the power station is very high.

With regard to sulphur dioxide and sulphur trioxide, only in the British power industry has any attempt been made on a commercial scale to wash flue gases for the removal of these elements. These experiments have been extremely costly. The Battersea plant cost about £1,500,000, or perhaps £2,000,000 at present-day prices. The cost is equivalent to an additional 10s. per ton on the coal burnt. The processes in use require enormous quantities of water, which are not generally available. Other processes are being investigated, including an ammonia process, but they are still in the development stage. One of the great weaknesses of the processes is that they involve the cooling of the gas, thus causing it to fall to the ground quicker, possibly giving rise to a higher concentration of sulphur dioxide at ground level with the washed gas than would occur if the gas had been discharged hot from a high chimney. We believe that to discharge such a gas from a chimney 300ft high, the gas rising to 450ft or 600ft probably, is the best way to disperse it, for we believe that by the time the gas reaches the ground its concentration will be harmless.

I was very glad indeed to hear Dr. Foxwell emphasise the need to find out precisely what it is in the smog which is harmful. There is a great danger that enormous sums of money might be spent on eliminating the wrong thing. Nobody knows clearly just what in smog is harmful.

Dr. C. N. Davis (London): I think that the paper may lead some of the audience to overestimate the effect of air pollution ordinances in cities of the United States, while failing to appreciate the economic and social factors which have been significant there, as in England. For example, the number of coal-fired heating appliances in Pittsburgh decreased in the ratio of 2·4 to 1 between 1940 and 1950, and, in the same period, the number of appliances using gas increased in the ratio of 1 to 4·1. Natural gas piped from Texas, which is very cheap, was mainly responsible for this change. It contains very little sulphur. Another relevant factor, to which the author refers, has been the conversion of rail and road transport to diesel, again for economic and social reasons. John L. Lewis has been described as the best salesman for oil in the United States.

In Los Angeles social and economic factors have worked to increase distressing effects from air pollution instead of the other way, as in Pittsburgh. This is because of the large number of cars and a change in the petrol which they consume. A higher yield of petrol is obtained from crude oil by the modern catalytic cracking process than by the old fractional distillation. Cracking produces branched chain and unsaturated hydrocarbons which are not found in straight-run petrol. These compounds, when released into the atmosphere, are oxidised into irritant substances which are harmful to plants and animals. It is worth noting, too, that catalytic cracking introduces cancer-producing compounds which are not present in straight-run petrol.

There have been many instances of pollution following industrial expansion in North America, though little attention has been directed to such sources in the British Isles, where preoccupation with domestic fuel may have been a distraction. As the smoke pall from coal lifts, it is unlikely that the pollution problem will disappear with it.

Dr. A. Parker: I should like to tell the

author that we in this country in our survey of the incidence of pollution have advanced considerably in the last few years because of the growing interest in the subject, an interest which has been particularly stimulated by the smog of December, 1952. We now have in regular operation throughout the country, with the co-operation of the various local authorities and other organisations, more than 1400 pollution measuring gauges, and in addition we ourselves, centred on our own research station, have roughly 100 gauges in use for special surveys trying to find the distribution of the pollution and the changes in intensity at different times of the year, and so on. Most of our problem comes from the use of coal for fuel. We have no large supplies of oil or natural gas to replace that coal. Therefore we have to continue to use coal or coal derivatives.

With regard to sulphur, as Mr. Peterson said, work is going on now upon the removal of sulphur dioxide from flue gases. In general, the concentration of sulphur dioxide in the flue gases from power stations in this country is less than the 0·2 per cent given as the limit in the ordinance for Los Angeles. Therefore, most of our power stations would pass that ordinance without doing anything at all. There are prospects of having a process using ammonia to produce a concentrated gas liquor. It will produce ammonium sulphate, and it is a process which may bring a return. We are working on this and are in co-operation with the British Electricity Authority, and there are some hopes that the process will be employed, at least in special cases. With smelter gases the problem is easy because the concentration of sulphur in the gases is much higher and there is a better chance of getting an economic method.

Dr. H. Heywood: In presenting the complex problem of air pollution the author has shown how many different facets of science and engineering are involved in the solution.

The physicists have been studying the problem of dust measurement for very many years. At a conference of the Institute of Physics earlier this month all the problems were discussed very fully indeed, and the conclusion was suggested by some of the people at the meeting that the development of physics and physical methods has now reached a stage which is sufficient for the immediate purposes. The present need, which is most urgent, is to develop a transitional stage between the physical studies and the application to practical problems. The paper that we had a week ago by Laurie, Holman and Thomas is an illustration of that idea of development, which is purely the field of the engineer. In these ways I think that it is the engineer with a basic knowledge of physics who can render invaluable service in the design of efficient dust collecting equipment, for many of the early designs have been based on processes of trial and error without there being a sufficient knowledge of particle dynamics.

Mr. F. S. Mallette, the author of the paper, replied briefly to the discussion.

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NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—It has been announced by the North-East Coast Institution of Engineers and Shipbuilders that Mr. P. L. Jones, a director of Swan, Hunter and Wigham Richardson, Ltd., and of Wallsend Slipway and Engineering Company, Ltd., has been elected president and that Professor L. C. Burrill, head of the Department of Naval Architecture and director of Naval Architecture Research Laboratories, King's College, has been elected vice-president. The new ordinary members of council are Messrs. G. B. Halley, D. G. Ogilvie, A. Storey, S. C. Swan, and D. A. Wrangham, representing the Non-Associates' Section, and Mr. W. F. Blackadder, of the Associates' Section.

# Aeronautical Compound Diesel Engine

*In the "Nomad" engine the cycle of a loop-scavenged two-stroke diesel engine is compounded with that of a gas turbine. An overall compression ratio of 31·5 : 1 and expansion ratio of 24 : 1 is achieved, leading to a fuel consumption in the order of 0·35 lb/b.h.p.-hour. Boost and fuel consumption can be maintained relatively constant over unusually great altitude changes, the former made possible by the use of an infinitely variable gear before the turbine. The division of work permits the gas turbine to contribute substantially to the crankshaft output through gearing, apart from its principal task of charging the diesel engine. Total power (sea level take-off) developed in the gas turbine alone is 2250 h.p. and in the diesel engine alone 2660 h.p. The unit is rated for take-off at 3046 h.p. at the propeller shaft.*

FULL technical details have now been released by D. Napier and Son, Ltd., of the "Nomad" compound diesel engine (Fig. 1). Mention was first made of this power plant just prior to the S.B.A.C. show in 1951, and brief references have been made in these columns to its subsequent development. Since its conception, advances in axial compressor design have been exploited and a single axial compressor replaces the original use of axial and centrifugal compressors in series.

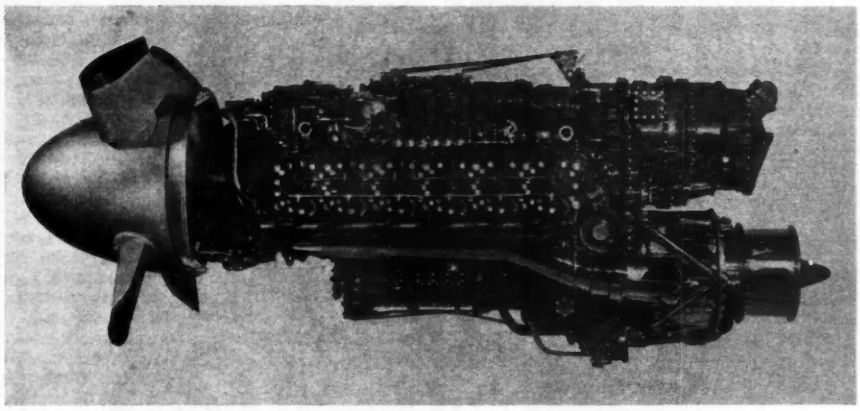


**Fig. 1—"Nomad" Compound Diesel Engine; Fuel Consumption at Maximum Power of 3046 s.h.p., 0·355 lb/s.h.p./hour. Specific Weight 1·1 lb/h.p.**

Fig. 2 conveys simply the extent of the thermodynamic and mechanical compounding achieved in this engine. It will be seen that the compressor, which has a maximum compression ratio of 8·25 : 1, charges the diesel engine with combustion air, which then undergoes further compression in the diesel cycle. The products of combustion are exhausted to atmosphere across the turbine, the expansion ratio in this unit being 4·6 : 1. The maximum power developed in the turbine is 2250 h.p., of which 1840 h.p. is absorbed by the compressor, the remainder passing directly through the quill shaft and gearing to the crankshaft. The diesel engine operates on a two-stroke cycle with loop scavenging, the high-pressure scavenging air serving the important additional function of secondary air in the gas turbine cycle. The proportion of secondary air required is consequently reduced in such a cycle owing to the heat drop effected in the cylinders of the diesel part of the engine.

An infinitely variable gear between the crankshaft and turbine shaft, described below, is an essential factor in the arrangement, enabling the speed of the compressor to be retained within optimum limits. It is possible to maintain take-off boost (6·28 : 1) up to 7750ft. The compression ratio in the cylinders based on effective stroke is 8 : 1, giving an overall compression ratio of 31·5 : 1. An air mass flow of 13 lb per second satisfies the 40 : 1 air fuel ratio, dictated by cylinder performance, and the diesel engine alone at sea level (2050 r.p.m.) develops 2660

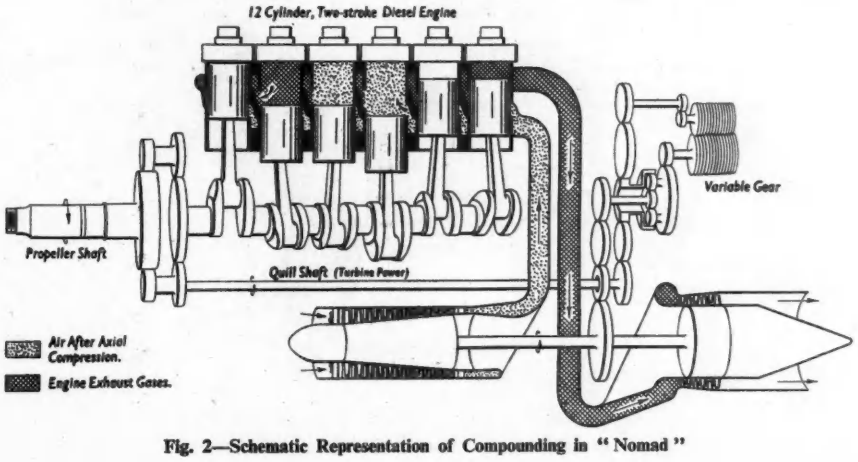



**Fig. 2—Schematic Representation of Compounding in "Nomad"**

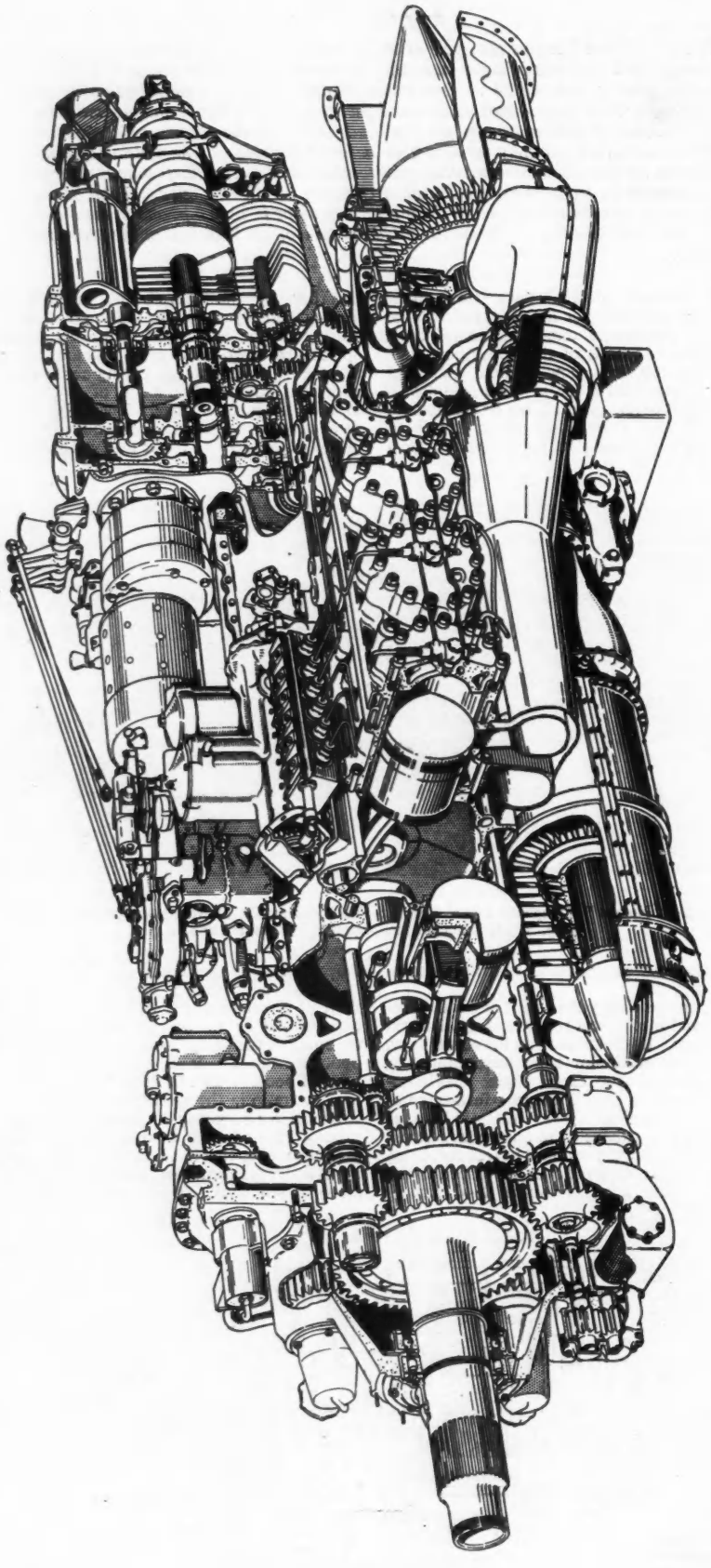


Fig. 3—General Arrangement of 3046 s.h.p. Compound Diesel Engine

s.h.p., i.e. 64·7 b.h.p. per litre with a mean piston speed of 2520ft per minute. Under these conditions it has been possible to retain piston ring temperatures no higher than those appertaining to diesel engines developing less than half this power with a similar piston speed. For an appraisal of the whole philosophy of compounding and the merits of this particular engine, readers are referred to the paper read recently before the Royal Aeronautical Society, an abstract of which is reproduced on page 647.

The engine derives from this arrangement several distinguishable characteristics. Its specific weight (dry) can be as low at 1·175 lb/h.p. (about that of radial engines of the same rating), and it has the lowest fuel consumption achieved in an aeronautical engine, due largely to the much higher overall compression and expansion ratios attained by compounding. The other important characteristics which distinguish it from all other prime movers are depicted in Fig. 8, which show how small are the variations

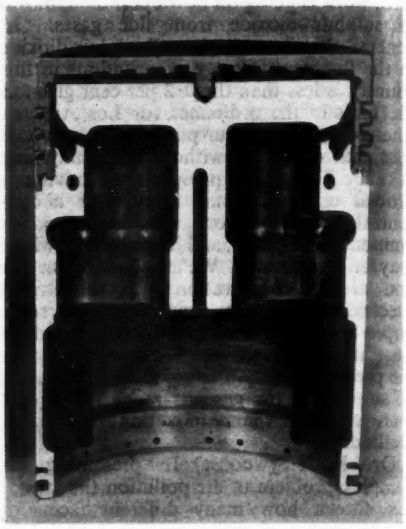


Fig. 4—Section Through Piston Showing Screwed Austenitic Steel Head Construction

in power and fuel consumption at a given output with altitude. Also shown is the relatively small variation in fuel consumption with shaft horsepower. It will be noted that at the recommended cruising conditions 1952 s.h.p. can be maintained virtually constant from 5000ft to 25,000ft, whilst the fuel consumption varies only between 0·327 lb/s.h.p. hour and 0·34 lb/s.h.p. hour at that rating.

### Constructional and Component Details

A general arrangement of the engine is shown in Fig. 3.

The diesel engine has twelve cylinders, horizontally opposed, operating on the two-stroke cycle with loop scavenging, the cylinder bore and stroke being 6in and 7½in respectively, giving a total displacement of 41·1 litres.

Magnesium-zirconium alloy has been used for the crankcase, which is split on its vertical centre line to permit assembly of the six-throw nitrided steel crankshaft, which is carried in thin-wall lead-bronze bearings. The two cylinder blocks are aluminium alloy castings and contain water jackets for cylinder cooling. Dry cylinder liners are fitted, which are of copper-chromium alloy and contain the inlet and exhaust ports. The scavenging system employed gives a well-defined air movement within the cylinder and combines effective scavenging of burned gases from the cylinder with minimum pressure losses.

The combustion chamber is formed in the cylinder head and is hemispherical in shape. It has a centrally situated fuel injector having one central spray orifice and five equally spaced radial orifices, the radial sprays being directed at the combustion chamber walls. The injector is of special design to suit the requirements of high-speed operation and high cylinder outputs.

The injection pumps are mounted in two

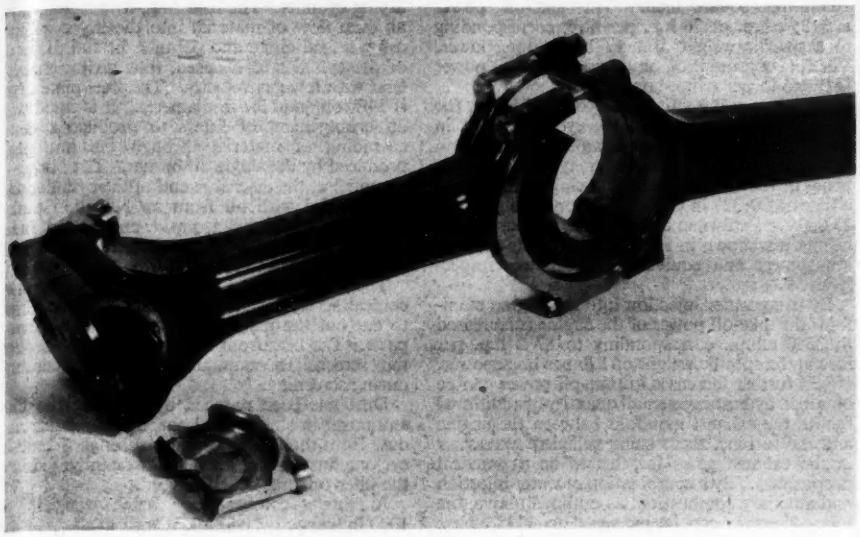


**Fig. 5—Connecting-Rod Details Showing " Slipper " Bearing Arrangement and Retention Straps and Covers**

blocks of six elements on the port and starboard flange positions on top of the crankcase. They are of " jerk-type " design, specially developed for operating at high speeds and specific outputs.

It can be seen from Fig. 4 that the pistons are of two-piece construction, comprising a Y alloy body with an upper portion in austenitic steel, which permits running at temperatures of upwards of 600 deg. Cent. at the centre of the crown at full power. Cooling oil, pressure fed from the crankshaft system through drillings in the connecting-rod, is provided and is directed at the region behind the piston gas rings to ensure that the ring temperature is reduced to a satisfactory working level.

Advantage has been taken of the substantially unidirectional loading on all connecting-rods, which results from operating on a two-stroke cycle, to use unconventional forms of big end and small end bearings, this being demonstrated in Fig. 5. It will be seen that both bearings are of the half-bearing or " slipper " design, with either straps or end caps fitted as safety devices to deal with the light loads in the reverse loading direction.

*The Compressor.*—The axial-flow compressor is suspended by four flexible links below the crankcase, as shown in Fig. 3, and its entry is arranged to take full advantage of " ram " air. It has twelve stages, a maximum pressure ratio of 8¼ : 1, and an air mass flow of 13 lb per second. Adjustable inlet guide vanes are employed to extend the operating range of the compressor at low speeds to match the requirements of the turbine, and these are automatically controlled. The rotor and stator blades of the first five stages are steel, the remaining stages being aluminium-bronze.

*The Turbine.*—The turbine, which is mounted coaxially with the compressor, has three stages and is designed to extract the maximum energy from the gases ; thus there is only a small amount of residual thrust. The turbine inlet pressure is 76 lb per square inch (absolute), the temperature 661 deg. Cent., and the maximum speed 19,800 r.p.m., the turbine blading being D.T.D. 736. It is attached to the rear gear casing of the engine by a tubular framework and, to accommodate expansion, both the turbine and compressor are connected into this casing by shafts having internally toothed couplings at each end.

*Rear Gear Casing.*—The rear gear casing is machined from a magnesium-zirconium casting and contains the main portion of the reduction gear train between the turbine and the diesel engine. In addition, it houses the oil sump, the oil pressure and scavenge pumps, and the coolant pumps and contains drives for the engine starter and auxiliary gearbox.

*The Infinitely Variable Gear.*—A housing attached to the rear face of the rear gear casing above the turbine accommodates the infinitely variable gear. This gear has been designed and developed by the company to suit the particular requirements of the " Nomad " application, but the basic scheme was evolved by Dr. Josef Beier and developed in Germany before the last war. It is an ingenious practical adaptation of the well-known scheme in which two conical members are end loaded together, the gear ratio being varied by sliding one cone over the other.

Details of it are shown in Figs. 6 and 7. A " pack " of discs with narrow conical rims are arranged on a central shaft and are spring loaded to trap a series of coned discs carried on three planetary shafts disposed around the central shaft. Each planetary shaft swings around a fulcrum to obtain changes in gear ratio and by attaching a gear to the planetary shaft meshing with one at the fulcrum it is possible to arrange a constant mesh gear system so that changes in gear ratio can be made while running.

In operation the gear is lubricated by high-pressure oil directed at the contact points between each flanged and coned disc. This prevents metallic contact between them, the power being transmitted through the drag force obtained by fluid shear of the oil film.

To reduce the dimensions and weight of the variable gear to a minimum it is connected into the gear system of the " Nomad " as indicated in Fig. 7.

Epicyclic reducing gear is employed between the turbo-compressor set, the variable-speed device being connected across two members of the epicyclic train. This, in effect, produces two mechanical systems in parallel, only about 30 per cent of the total power being transmitted through that part of the system in which the speed varying device is fitted.

### Engine Controls

The engine is fitted with a single lever control system, which relates the speed, boost and fuel functions together to ensure that a predetermined operating line is followed. The speed control is provided by a mechanically set constant-speed unit varying the propeller pitch. For each speed selected there is a fixed value for boost pressure

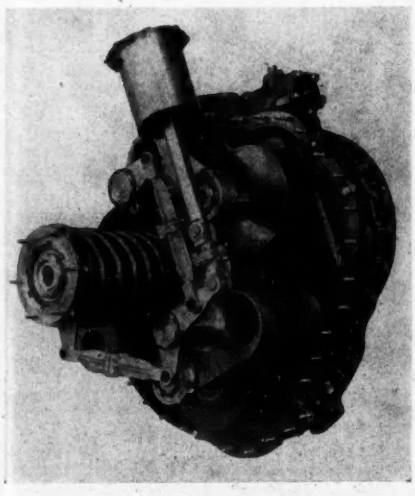


**Fig. 6—Details of Infinitely Variable Gear Showing Coned Planetary Disc Packs**

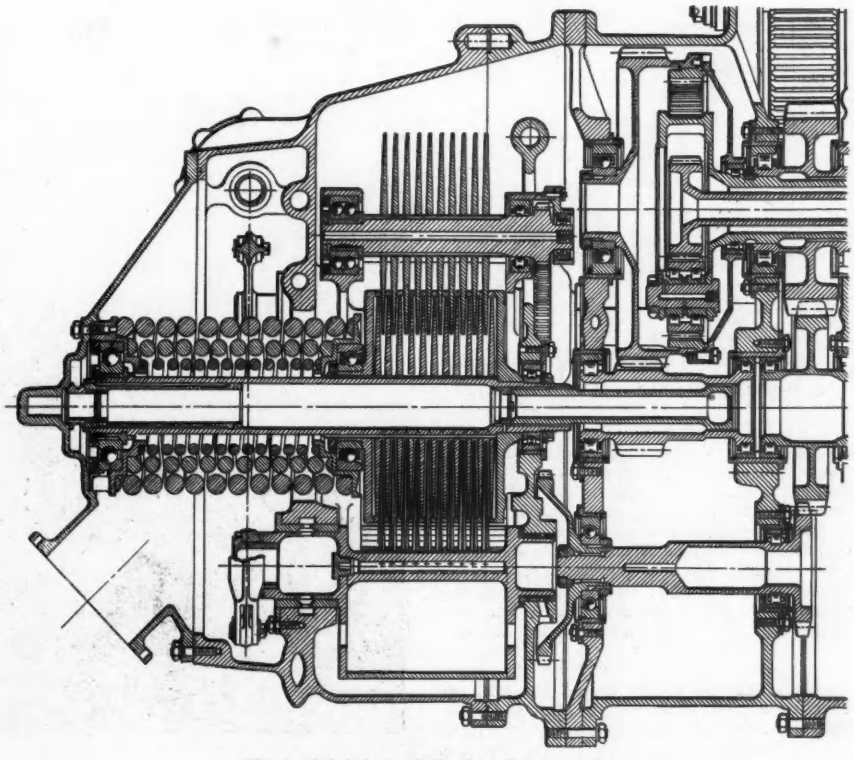
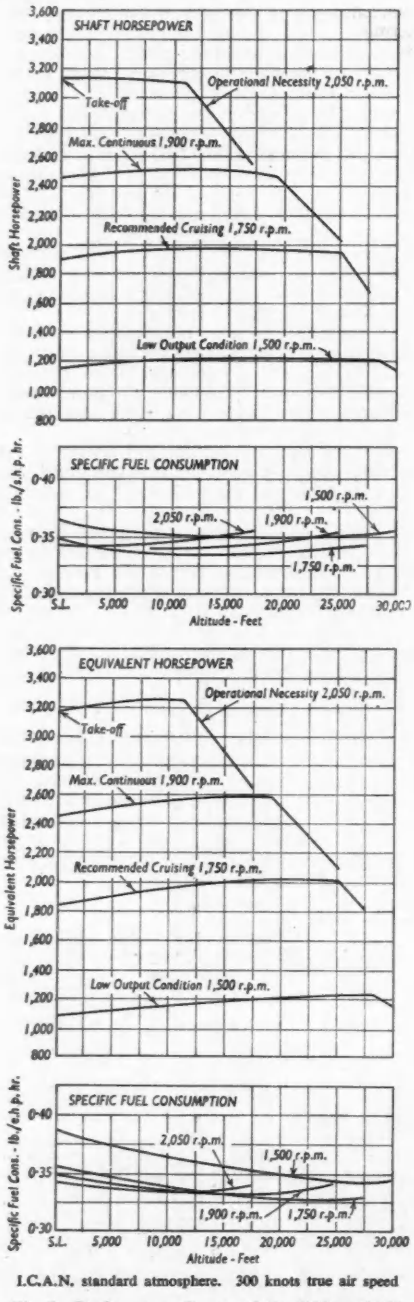


**Fig. 7—Infinitely Variable Gear Arrangement**

and for fuel flow. The boost pressure obtained is applied to a normal form of variable-datum boost control unit, the servo piston of which is connected by linkage with the control setting of the variable gear. By this means the gear ratio is automatically adjusted to speed up the compressor to maintain the selected boost pressure with increasing altitude until the maximum permitted speed of the turbo-compressor set is




I.C.A.N. standard atmosphere. 300 knots true air speed

**Fig. 8—Performance Curves of the "Nomad 2" Engine**

reached. This corresponds to the maximum power for that particular engine condition and above this point the fuel flow is reduced automatically by a resetting device.

*Starting.*—Starting is by means of a 112V electric starter, which is geared into the crankshaft system. As the compression ratio of the diesel engine is only 8 : 1 it is necessary to fit a sparking plug in each cylinder, energised by a high-energy ignition system of Napier design.

### Engine Performance

Under take-off conditions at sea level the effective overall compression ratio is 31·5 : 1 and the overall expansion ratio is 24 : 1, the boost pressure being 89 lb per square inch (absolute) and the brake mean effective pressure 205 lb per square inch. The take-off power is 3135 e.h.p. or 76 h.p. per litre, corresponding to a specific weight of 1·17 lb per horsepower. The fuel consumption based on equivalent power is 0·345 lb per e.h.p.-hour.

With increasing altitude up to rated height the overall expansion ratio of the cycle increases in sympathy and this leads to an improvement in specific fuel consumption, a typical example being at the recommended cruising rating where a figure of 0·327 lb per e.h.p.-hour is obtained at 25,000ft. Performance curves at various engine ratings are shown in Fig. 8, which relate to shaft horsepower and equivalent horsepower respectively.

By using water injection into the engine manifolds the take-off power of the engine is increased to 3580 e.h.p., corresponding to 87·2 h.p. per litre and a specific weight of 1 lb per horsepower.

Still further increases in take-off power can be obtained by burning a small quantity of additional fuel in the exhaust manifold between the engine and the turbine, there being sufficient excess air in the exhaust gases for this to be a practical proposition. By a combination of water injection and auxiliary combustion, as outlined above, the take-off power can be increased to 4095 e.h.p., corresponding to 99·6 h.p. per litre, the specific weight being reduced to 0·93 lb per horsepower.

Two further factors which arise from the nature of the operating cycle are worthy of mention. First, the engine is able to run effectively on a wide range of fuels, including diesel fuel, for which it was originally designed, kerosene and wide-cut gasoline. Secondly, the engine is practically insensitive to increases in ambient temperature, losing less than 2 per cent of its take-off power for each 10 deg. Cent. increase in temperature.

## Mobile Asphalt Mixing Plant

A MOBILE asphalt mixing plant with a capacity of 12 to 25 tons per hour has been developed by Frederick Parker, Ltd., of Leicester. It is known as the "Starmix" No. 8, and the maker states that particular attention has been paid in its design to obtaining full mobility and low operating costs by reducing wear and tear and heat losses.

The principal elements of the mixer will be apparent from a glance at the accompanying illustration. Aggregate is fed to the plant from a belt feeder, adjusted to supply the desired hourly capacity, and is then raised by a bucket elevator. The bucket elevator discharges directly into a feed ring, where chutes with scoop mouths pick up the material and discharge it into the drying cylinder. The feed ring, it is stated, gives an even flow of material into the dryer without using a feed chute and permits the full diameter of the cylinder to be used, thus giving an even heat with low gas velocity. The steel plate dryer is 14ft long and 3ft in diameter. It is fitted with an arrangement of lifters to produce a dense cascading of material through the hot gases produced by the single oil burner. The burner is mounted at the discharge end of the cylinder and is force fed with oil from an 80-gallon tank; burner controls are grouped on to two independent panels, one operated from ground level and the other from the platform at dryer level.

The hot stone is separated into three sizes by conical screens which are attached to the dryer to cut out the maintenance of separate moving parts. The heat from the dryer radiates through the screens to maintain a high temperature during screening.

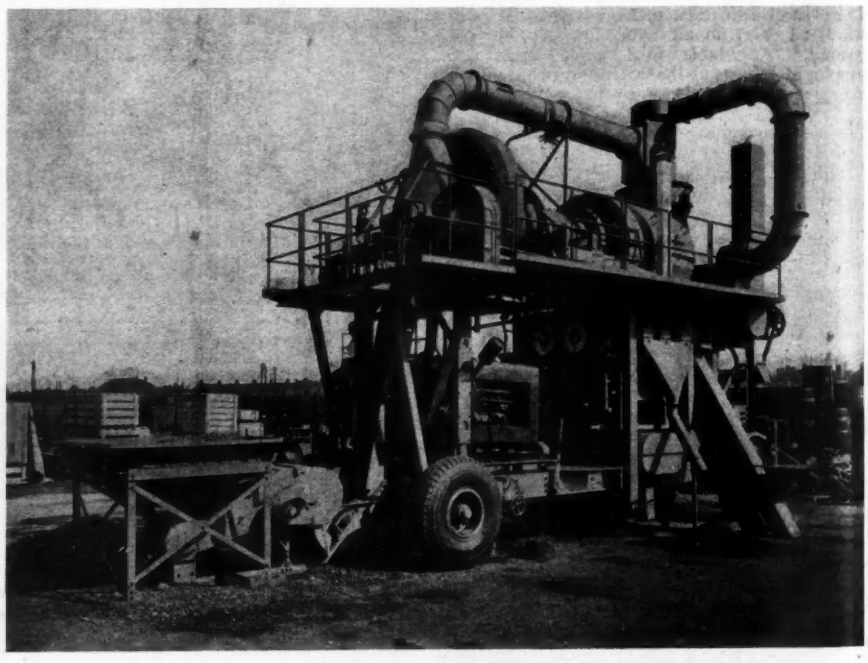
Dust has been reduced by encasing the bins and mixer in sheet metal panelling and drawing dust from the drying cylinder through a built-in cyclone dust collector. The dust can be fed into the filler or sand bin, if desired.

A single compartment batch weigher of 1000 lb capacity is built beneath the storage hoppers and connected to a weighing mechanism with its dial on the operating platform. There is a separate mechanism for the bitumen.

The double-shaft paddle mixer is a high-speed machine of 1000 lb capacity, capable of mixing a batch in under one minute. The paddle shaft bearings are free to move up and down, against compression springs, in vertical slides so that each end can rise or fall should a stone become trapped between a paddle tip and the mixer body. The shafts revolve in gunmetal bushes, which are protected from the dust by felt seals. The heat loss between drying and mixing is stated to be only 15 deg. to 20 deg. Fah. The controls for mixing, weighing and discharging are all centralised on one platform.

An enclosed filler elevator to take cement filler from the feed boot at the side of the plant to a storage bin may be added to the plant; in this case an extra compartment is also added to the aggregate weighing hopper. Also a 500-gallon oil-fired bitumen kettle with circulating pump may be mounted on the mixer platform. A hoist skip travels on a runway from beneath the paddle mixer to a discharge point 7ft off the ground for loading motor trucks. The plant is driven from one diesel engine fitted with a hand-operated clutch.

Lifting beams are provided to take off the dryer and lower it on to a motor truck when low travelling height is required. Similarly, the plat-



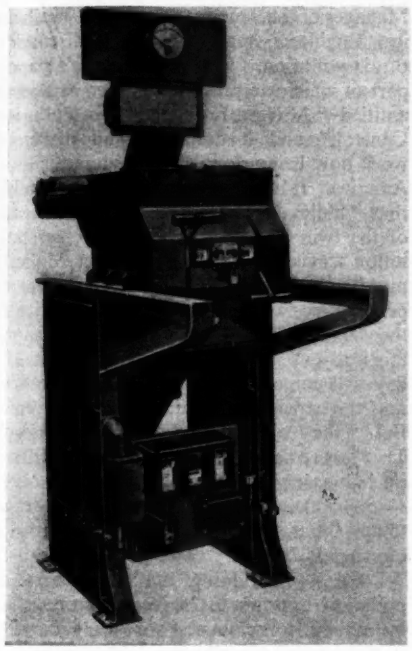
**Mobile Asphalt Mixing Plant**

forms can be raised to give narrow travelling width and the dust collector can be lowered down to give a minimum travelling height of 12ft or 15ft 6in with the dryer left on, and a minimum travelling width of 9ft.

## Fault-Making Load-Breaking Oil Filled Switch

We illustrate a new design of fault-making load-breaking oil-break switch, introduced recently by A. Reyrolle and Co., Ltd., Hebburn, Co. Durham. The new "IC27" switch is designed for being coupled directly to Reyrolle Class "C" switchgear, but is equally suitable for use either as an independent unit or for building into switchboards along with similar units.

The "IC27" switch has a normal current rating of 400A and consists of a switch chamber having a busbar chamber at the back, with current transformer accommodation and cabling arrangements below. In the switch chamber



Fault-Making Load-Breaking Switch

there is a main switch and an independent earthing switch. Both switches are designed to make and carry for three seconds, a current equivalent to 75MVA at 3·3kV, 150MVA at 6·6kV or 250MVA at 11kV, and the main switch is designed to break its normal rated current.

Both main and earthing switches are housed in a common welded steel chamber, which is carried across the frame standards. The main switch is of single-break swinging arm design, with fixed contacts consisting of heavy copper clips reinforced by steel leaf springs. Each moving contact is a gunmetal blade pivoted on a bracket carried by the lower through-insulator, with a laminated copper connection between the blade and the bracket. Operation of the moving contacts is effected by insulated links from arms on a common operating shaft above the oil. Insulating barriers are fitted between phases and between the sides of the chamber and the outer phases.

The earthing switch consists of copper blades fixed to an operating shaft and engaging with fixed copper clip contacts on brackets carried by the lower through insulators. The blades are bonded together by a copper bar which is connected by laminated copper to an earth stud on the case. The fixed contacts on the earthing switch and on the main switch are interchangeable.

If the main switch is closed on a fault or if the earthing switch is closed on a live circuit the electromagnetic forces that are set up are such as to assist closure. Similarly the contacts are so designed that the passage of current increases the contact pressure.

Both the main switch and the earthing switch are manually operated by mechanisms which are arranged side by side at the front of the switch chamber, with a protective cover which can be removed for maintenance. A positive bolt-interlock prevents simultaneous closure of both switches and the operating handles can be padlocked in any position.

The busbars are of 1·5 square inch copper laminations insulated with bakelised paper and supported by moulded insulators at the ends of the chambers, which are compound filled.

Test orifices are provided at the top of the switch chamber and they are covered by a padlocked, hinged, mild steel door. There are plugs for insulation resistance testing and single-phase high-voltage testing. An interlock ensures that the earthing switch is closed before the testing plugs are inserted; thereafter the earthing switch can be opened for testing. Before the main switch can be closed the testing plugs must be removed. If required, neon lamp indication can be provided to show whether the circuit is alive. In this case the lamps would be energised from condenser bushings fitted in the bottom of the switch chamber instead of the standard porcelain through insulators.

## Improved Form of Buchholz Protective Relay

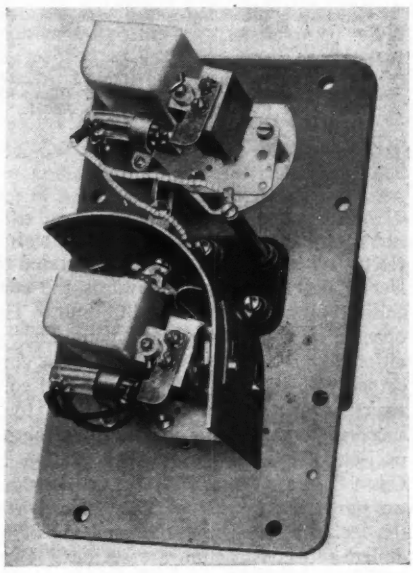
We illustrate an improved design of Buchholz type gas-actuated protective relay which has been developed by the English Electric Company, Ltd., Stafford, and has recently been approved by the British Electricity Authority for use on contracts for oil-filled transformers. This relay is distinguished by the fact that it detects incipient faults and, by giving an alarm, enables action to be taken before the fault can cause extensive damage to the protected apparatus. Three sizes of relay are available for 1in, 2in and 3in pipework. The relay employs two bucket type operating elements which are contained within the casing, the upper element operating an alarm when a certain volume of gas has been collected owing to an incipient fault, and the lower element operating to isolate the transformer either on complete loss of oil in the conservator and relay or when a more serious fault causes an oil surge. The bucket type operating elements give positive operation, and are so designed that the operating values for steady flow and sudden surge are approximately the same; the relay can therefore be used with confidence on transformers having forced oil cooling, because greater surges caused by starting the

Buchholz Gas-Actuated Relay

circulating oil pump can be tolerated without inadvertent tripping. A novel hand-operated testing device enables the electrical alarm and tripping circuits to be checked rapidly.

As shown in our second illustration, each operating element assembly consists of an aluminium bucket pivoting on journal type bearings and counterbalanced by a nickel-plated mild steel weight. Both upper and lower assemblies carry a mercury switch clamped to the balance weight, and leads from the switch are taken to a moulded terminal block. The special curved mercury switch gives positive operation on both the "slow" make of the upper assembly and the "fast" make of the lower element. This form of switch, with mercury-to-mercury cup contact eliminates the oscillatory action usually encountered when the alarm element is near its operating point. Baffle plates attached to the lower assembly cause it to tilt when struck by an oil surge. A deflector plate is provided on the larger sizes of relays to reduce sensitivity so that a standard lower assembly can be employed on all relays.

An inspection window is fitted in the relay



Mechanism of Buchholz Relay Showing Buckets and Curved Mercury Switches on Upper and Lower Assemblies and the Baffle Plate on the Lower Assembly

casing through which the oil level can be checked against a graduated dial, as can be seen from our first illustration.

With both upper and lower elements under normal conditions the balance weight is predominant and the assembly is tilted to the open position. If a slight fault occurs in the transformer the gas generated will be trapped in the relay housing. As this gas accumulates the oil level will fall, leaving the top bucket full of oil. The extra weight due to the contained oil will then overcome the balance weight, and the assembly will tilt, closing the mercury switch and operating an alarm. A pet cock is provided at the top of the relay for taking samples and releasing gas from the chamber.

With a serious fault the gas generation is rapid, causing the displaced oil to surge through the relay. The flow will impinge on the baffle plate of the bottom element, causing it to tilt and close the mercury switch. This will complete the trip circuit to isolate the transformer from the supply. The relay will operate satisfactorily for rising pipe angles between 1 deg. and 9 deg.

The hand-operated testing device consists of a bracket with two arms on the top edge of each bucket. Manual rotation of a small shaft, protruding through an oiltight gland into the terminal box, tilts the upper and lower operating elements to the "switch closed" position. The position of the testing device is shown by the position of a pin moving in a slot on the graduated dial. A lower pet cock can be provided, if required, for testing by air injection.

# THE ENGINEER

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## OWEN FALLS

As we go to press the Owen Falls hydro-electric scheme is about to be inaugurated by Her Majesty the Queen, towards the conclusion of her Commonwealth tour. The opening ceremony brings well-merited recognition to all of those who have been concerned with the promotion, design and construction of the scheme, and brings to a successful conclusion a bold and imaginative project. The dam and power station at Owen Falls are described in the article which we start on page 627 of this issue, where the technical problems and methods of its design and construction are set out. Even fuller details will be given in the papers to be presented at the Institutions of Civil and Electrical Engineers next month. We need not repeat any of the description here, save to mention that the scheme's technical novelty lies in the exceptional facilities for storage and regulation of the river flow, at a favourable site. The temporary river works also offer technical interest, and, in fact, the contractor's side of the work was unusual, both in the execution of the river works and in problems of organisation, as may be judged from the fact that 300 Europeans, 150 Indians and 2000 Africans were employed at the site. The considerable financial risk inherent in the uncertainties of such a remote scheme was borne by a consortium of eight firms, who had previously worked together in the reconstruction of the port of Rotterdam.

But the full significance of the scheme will not be appreciated from its purely technical aspects. In fact, it follows generally conventional practice in many respects for a scheme of its kind, and it is not remarkable for its size in comparison with major developments in other parts of the world. The Owen Falls scheme differs because it has been built in an undeveloped area, so as to create an electricity supply industry, and hence to make possible the industrial development of Uganda, which is so important for its economy at the present time. The extent to which this pioneering policy behind the Owen Falls scheme has been successful will be apparent from the figures given in that section of our article entitled "Development of Electrical Load in Uganda," and we need only repeat here that the Uganda Electricity Board considers that when its electrical load is more developed it will be able to offer industrial tariffs amongst the lowest in the world. For a country which relies on imported fuel and is 800 or so miles by rail from the nearest seaport, the importance of such an amenity can hardly be over-estimated.

There is also another aspect to this opening ceremony. In the British Colonies and Protectorates in Africa there exist vast possibilities of development, both industrial and agricultural. Mankind stands in great need of these developments, both in Africa and in other parts of the world, where attempts such as the Colombo plan are being made to improve the lot of millions of people. Before such development is possible, however, civil engineering works on a vast scale have to be undertaken, for the provision of the basic amenities of civilised life, such as roads and ports, and control of river catchments for irrigation and water supply, and the generation of electrical power. Appreciable progress along these lines is now being achieved in the British African territories. Developments on a vaster scale than the Owen Falls scheme, such as the Volta River project in the Gold Coast and the Kariba Gorge project in Rhodesia, have been investigated in some detail during the past few years, whilst actual constructional work on other schemes in the African Continent has been maintained on a considerable scale by British engineers. A good example of their achievements is given by recent progress in harbour construction; harbour works at Takoradi, Tema (the port of the Volta scheme), Lagos, Freetown, Dar-es-Salaam, and Mombasa, are now in progress or have been recently completed. Other developments have followed, and more still, doubtless, are to come, making use of these basic facilities. We look upon the Owen Falls scheme, which is the first major development of its kind in Equatorial Africa, as a portent of further development to be achieved in the not-too-distant future. It provides a fine example of the benefits which well-planned engineering development can bring to the whole of Africa. It is, judged by some others, a modest scheme. But it is a pioneering one, and it has paved the way for others to follow.

## CONTROL OF AIR POLLUTION

Last week, as the consequence of the arrival at this office of a number of documents having relevance to the subject, we drew attention to water pollution and what is being done about it in this country. Now, the presentation before the Institution of Mechanical Engineers of a James Clayton paper by Mr. Frederick S. Mallette, Research Manager of the American Society of Mechanical Engineers, suggests to us a discussion of air pollution. For Mr. Mallette's paper, part of which we print on another page, was entitled "A New Frontier: Air Pollution Control," and it described and discussed work now being done and progress made in America. It is not, perhaps, very remarkable that public consciousness of the existence of the twin problems of air and water pollution seems to be related. As Mr. Mallette put it, "Air and stream pollution-control programmes are moving ahead at practically the same pace." He added, perhaps optimistically, "it is not improbable that the day will come when neither the atmosphere nor the streams may be used as sewers." But "the cost will be truly staggering." That last remark, though undoubtedly true—for immense problems of control are involved—sounds depressing. Mr. Mallette hastened to add "but man never baulks at the price of progress."

Progress in ridding the atmosphere of pollution appears to be very largely ruled by public consciousness of what damage is done by that pollution. It may be significant that really considerable advances do not seem to have been made in the United States until the post-war years; perhaps it would be more relevant to write until a thick and fatal smog covered the small town of Donora for five or six days in October, 1948. Some twenty people died, many others were rendered ill and sensational accounts in the press and on the radio made the nation aware of what was happening even before the smog had dispersed. Similarly, but in a less sensational way, the great smog that enveloped London in December, 1952, and the growing realisation in the weeks that followed that there had been a disaster of very high magnitude, responsible for some thousands of deaths, drew the attention of the public in this country to the subject. The invitation extended by the Institution of Mechanical Engineers to Mr. Mallette to read his paper is, no doubt, in itself an example to show how that event emphasised the need for the control of air pollution. For it is an appalling thought that the threat of a repetition hangs over London each winter. Undoubtedly, were the public determined that something should be quickly done some of the

pollution of London's air—and that of other cities in this country—could within a very few years be removed. A few places in America, as instanced by Mr. Mallette, demonstrate that point. Again, some of the pollution could be abated very quickly if certain industries and firms were to realise that inefficient combustion wastes fuel as well as polluting the atmosphere—a thing many no doubt realise already—and were to gain a sense of urgency about the fitting of improved combustion appliances. But the problem in this country is in one respect more difficult to solve than it is in America. For here the public remains largely wedded to the open coal fire and the burning upon it of bituminous, smoke and fume-producing coals. In American cities there are few sources of atmospheric pollution in relation to the populations involved; but here there are vast numbers each individually making an insignificant contribution, but *in toto* producing more pollution than do power stations, factory chimneys and the like, the emission of smoke from which is at least partially under some legal control. Can the British public be made to realise rapidly how much pollution their open fires produce? Can smokeless grates, and smokeless fuels be made quickly in large quantities? Above all, can the public be made to realise that industry cannot be expected to adopt expensive remedies (as, for example, the insertion of washing plants in power station chimneys or the fitting of devices for the prevention of the emission of fumes and ash from steelworks) unless that very prevalent source of air pollution, the coal fire, is subjected to some control and the public is willing to pay the cost of improvements?

But though, given public support, some action could be taken within the space of very few years to bring alleviation it would be the sheerest optimism to hope that the atmosphere over Britain could by then be rendered wholly clean and inoffensive. With air pollution as with water pollution, industrial operations must go on whether or not effective means of dealing with effluents, whether liquid or gaseous, have been discovered. By no means all industrial operations liable to emit smoke or fumes are easily adaptable to remedial measures. Very far from all is known even about the effects upon human beings of polluted atmospheres. It is notable, for example, that both in Donora in 1948 and in London in 1952 concentrations of sulphur dioxide were far below the concentrations deemed to be safe, and yet proved fatal to many. No really reliable estimate can be made of the savings in wastage of buildings, in washing, cleaning and painting, in public health expenditure and the like, which would follow upon effective anti-pollution measures. Let us return to Mr. Mallette. "Not all of this future betterment will be as easily accomplished as it is imagined. Many of the problems defy efforts at control, either from an engineering or an economic point of view. Some way will be found to meet the cost, but the technical difficulties can only be solved by the ingenuity of engineers. For them, air pollution control poses a tremendous challenge—it is indeed a new frontier."

# Obituary

## E. GRAHAM CLARK, C.B.E.

We regret to record the death of Edmund Graham Clark, C.B.E., M.C., M.Sc., M.I.C.E., which occurred on April 23rd, after a short illness. Mr. Graham Clark had been secretary of the Institution of Civil Engineers since 1937, and was sixty-four years of age; he was due to retire from his post as the Institution's secretary in August.

Mr. Graham Clark was educated at Felsted School and Durham University, where he obtained his degree in engineering in 1910. He then served a pupilage with the consulting engineer, J. Mitchell Moncrieff, to whom he later became an engineering assistant, gaining experience on various works on the River Tyne during this period. In 1914 he joined the staff of the Institution of Civil Engineers as a technical and editorial assistant, and in the same year he was elected to Associate Membership of the Institution.

On the outbreak of the first world war, as a territorial officer Mr. Graham Clark was mobilised in August, 1914, and saw active service in France and Belgium, with the 50th (Northumbrian) Division. He had become a staff captain before he was demobilised in 1919. After demobilisation he rejoined the staff of the Institution as chief technical assistant and spent the rest of his career serving in various capacities on the Institution's staff. In 1933 he became chief assistant, and early in 1937 was appointed acting secretary, being confirmed in the post of secretary at the end of that year, in succession to Dr. H. H. Jeffcott. During the period when he was chief technical assistant he acted as secretary to a number of technical committees, amongst the most important of which were the committee reporting on the tabulation of the results of heat engine trials, the committee on engineering quantities, and the committee on floods in relation to reservoir practice.

During his secretaryship of the Institution of Civil Engineers Mr. Graham Clark played a leading part in furthering the intimate relationship which now exists between the Institution of Civil Engineers, the Institution of Mechanical Engineers, and the Institution of Electrical Engineers. Subsequently he was active in the work of encouraging co-operation between the principal national engineering societies in the Commonwealth and in Western Europe and the United States of America. This work has resulted in the creation of the Conference of Engineering Institutions of the British Commonwealth and the Conference of Representatives from the Engineering Societies of Western Europe and the United States of America, to consider matters of common interest between the engineering societies and institutions of those various countries.

Mr. Graham Clark became a member of the Institution of Civil Engineers in 1938, and was created a C.B.E. in the New Year Honours of 1948. In 1953 he was awarded an honorary M.Sc. degree by Durham University.

# Letters to the Editor

*(We do not hold ourselves responsible for the opinions of our correspondents)*

## EMPLOYMENT OF THE ELDERLY

Sir,—The article "Employment of the Elderly," by L. Bagrit, in your issue of April 23rd, page 614, made inspiring reading. It is indeed refreshing to learn that there are people in our midst who are courageous enough to tackle the problem of the rehabilitation of the aged in industry. We in this country have always displayed a certain reluctance to employ the elderly. Our minds tend to place people and phenomena into rigid categories; it is an easy way of disposing of difficulties and awkward problems. It becomes simple, therefore, to think of old people as a group of seniles hobbling about the house or pushed around in wheelchairs. The truth, on the other hand, is that it is not the number of years which determines age, but rather the attitude of mind. These youthful veterans can undoubtedly make a worthwhile contribution to industry. Those among them who perhaps lack the stamina of earlier days still possess the valuable asset of a life experience. To find a place for the elderly in industry is accordingly not only an appreciative gesture on the part of the managements, but a sound economic policy, very necessary in these days when increased productivity is a national desideratum.

One is aware that several firms beside Mr. Bagrit's have profited from the wise use of elderly labour. It is hoped, however, that Mr. Bagrit's timely article will induce many industrialists to reflect on and possibly to emulate his admirable example.

S. C. McKenzie

Rugby, April 23rd.

## WATER POLLUTION

Sir,—May I draw attention to a point which your leading article on water pollution in the issue of April 23rd might have made? I refer to the importance in this connection of records of measurement of the flow and character of our rivers.

In considering the effect of a given effluent on a given river, the degree of dilution is the dominant factor. To assess it, there must be knowledge of the flow of the effluent and of the flow of the river. The flow of the river varies from season to season and from year to year, and the required data can only be achieved by regular measurements over a series of years.

As you say in your leading article, the demands of people in this country grow for water for household and industrial use, and it becomes more essential to preserve and increase the sources of supply of pure water. In addition, a new factor is likely to appear, if the present campaign to promote irrigation succeeds. The more the demands grow, the more necessary it is that records of the flow and quality of our rivers should be available.

Yet the Ministry of Housing and Local Government closed down the Inland Water Survey two years ago. This was the central body set up by the Government to perform (to quote an official statement), "the task of making available to Government Departments, water undertakers, industry, agriculture, and, indeed, to all who need it, information as to the yield, behaviour and quality of the country's water resources."

Having closed down the Inland Water Survey, there is now no organ of any department of central government having any responsibilities of any kind for securing this essential basis of proper river conservancy.

The Inland Water Survey Committee—which still exists, although the Ministry has suspended its activities for two years past—gave in its sixth report to the Minister a full account of the reasons why the work of inland water survey should be intensified. That report was not printed by the Ministry, but the *Municipal Journal*, in its issue of April 16, 1954, has performed a useful service in making the essence of it available to interested parties. The case for the immediate resumption of the survey is overwhelming, and it is much to be hoped that the Government will take action.

M. G. Ionides

London, W.8,
April 27th.

## Literature

*Protective Atmospheres.* By A. G. HOTCHKISS and H. M. WEBBER. London: Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 56s.

THIS American book has been written primarily to assist the practical man who is in day-to-day contact with the use of protective atmospheres for various purposes. The authors are on the staff of the industrial heating department of the General Electric Company (U.S.A.), and therefore possess an intimate knowledge of the plant and processes which they describe. In their Preface they point out that the book is not intended as a scientific treatise on the subject, but is meant to serve as an operating manual.

The book opens with a brief description of the essential purposes of protective atmospheres in certain industrial fields. In the metallurgical field protective atmospheres may be used to shield a metal surface undergoing a hot process from oxidation, reduction and decarburisation or recarburisation. Inert atmospheres are employed in the chemical industry in numerous instances in order to prolong the life of parts of the plant, avoid the destruction of vitamins or guard the installation from an explosion hazard due to the presence of finely divided dusts, &c. In certain cases, such as atomic hydrogen arc welding or the removal of scale from steel by the sodium hydride pickling method, a powerfully reducing atmosphere is deliberately employed.

All the applications of protective atmospheres considered in this book are very neatly summarised in the form of a table on page 6 of the text, while on page 4 the approximate compositions and costs of production of the various types of protective atmosphere have been set out, again in the form of a table. Thus the industrialist seeking the information which applies to his own particular trade can very quickly come to grips with the essential data which he wants. The applications of protective atmospheres to various operations which are dealt with in this book may be summarised as follows:—

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|---|---|---|
| Heat and surface treatment of metals | ... | Annealing, normalising, hardening, carburising, nitriding |
| Joining of metals | ... | Brazing, sintering of powdered metals, arc welding |
| Chemical processes | ... | Prevention of oxidation, fire or explosion hazard in the paint, varnish, rubber and food industries, hydrogenation of oils, fats, &c. |
| Others... ... ... | ... | Descaling with sodium hydride |

The kinds of protective atmosphere considered are hydrogen, nitrogen, carbon dioxide, argon, helium, cracked ammonia and partially burned town's gas, the table giving details also of different methods of producing and treating these atmospheres for different applications. The approximate cost per 1000 cubic feet of each protective atmosphere is estimated in dollars, certain assumptions being made for the cost of electric power, water, ammonia, &c.

The second chapter of this book is devoted to a consideration of the basic chemical reactions of the gases used in furnace atmospheres, and tables are used to summarise the essential effects of the different atmospheres on iron and iron carbide and on copper and copper oxide. The effects of the water-gas reaction equilibrium are also described. The authors admit that theoretical considerations would seem to make the use of protective atmospheres a complex business, but then assure the reader that actually the applications are quite simple. Chapter 3 is devoted to the atmospheres used to prevent oxidation, Chapter 4 to those used to prevent decarburisation, and Chapter 5 to carburising, recarburising and nitriding.

In Chapters 6 and 7 the authors consider in some detail the problems of analysing, controlling, measuring, storing and handling these various atmosphere gases, including a description of the safety devices which may be employed, while the last two chapters, which amount to about two-fifths of the length of the whole book, consider in detail the application of protective atmospheres, more particularly to heat-treatment in furnaces, and finally the remedies which should be applied when, for one reason or another, the protective atmosphere fails to operate with the desired degree of efficiency. The book concludes with a table entitled "When Things Go Wrong," which is designed to guide the reader in tracing the trouble and pin-pointing the page in the book which deals with that particular aspect of failure.

This book will prove very useful to the practical fuel technologist and heat-treatment metallurgist, but, of course, it must be borne in mind that much of the practice referred to is essentially American and may not have a counterpart in Great Britain, where, for example, natural gas is unobtainable. The devaluation of the pound, of course, means that the price is distinctly on the high side for a book of this kind.

*The Manufacture of Iron and Steel.* By D. J. O. BRANDT. London: English Universities Press, Ltd., St. Paul's House, Warwick Square, E.C.4. Price 15s.

THIS book, published under the auspices of the British Iron and Steel Federation, is written primarily for those engaged in the steel industry who are preparing for the City and Guilds Examinations in Iron and Steel Manufacture. The author is a member of the Steelmaking Division of the British Iron and Steel Research Association, and his direct experience, combined with information supplied by the Federation, ensures that the work is authoritative and thoroughly up to date. The book deals mainly with the practical aspects of iron and steel making, the production of castings in iron and steel, and steel finishing processes for various carbon steel products, such as rails, plates, bars, sections, sheet and strip, wire, tubes, &c. There is a short account also of the surface coating of steel products, including continuous electrolytic tinning and electro-galvanising. Added interest is given by incidental historical references throwing light on the origin of various processes. Treatment of the chemical and physical theory involved is elementary throughout, but is adequate to an understanding of the plant described. There is, however, a short description of the structural constituents of steel, and the effect on structure of mechanical working and thermal treatment.

The scope of the book is evidently limited in some directions by the syllabus of the examination. In the main text there is little reference, except in general terms, to mechanical properties, nor to alloy steels, nor to any form of heat-treatment except annealing, normalising and the patenting process applied to wire rod; but methods of mechanical testing are briefly described in an appendix, and so also are some alloy steels and their heat-treatment. Other appendices deal with steel works refractories and pyrometry and, as a reminder that the book is intended for students, Appendix 5 contains some useful advice as to how to set about answering examination questions. It is good to see that emphasis is placed on the value of neat, freehand sketches, accurate in principle and clearly labelled. It is to be regretted that many metallurgical students of all grades are deficient in this form of expression.

The use of the volume as a textbook is aided by a foreword at the beginning of each section, and by chapters devoted to recapitulation, illustrated by diagrams showing the inter-relation of various sections of the industry. It is, however, different from the usual textbooks, in that its aim is not merely to describe the processes from the smelting of the ore to the final finishing operations, but also to examine the way in which steel works are built up, where they are located and the part played by the industry in the economic life of the nation. There can be no doubt as to the value of the book to candidates for the City and Guilds Iron and Steel Operatives' Examinations, and it can also be strongly recommended to those less directly concerned with steel works practice as giving an interesting and concise account of the origins, development and present position of the steelmaking industry in this country.

## Institution of British Agricultural Engineers

THE annual general meeting of the Institution of British Agricultural Engineers was held in London on Wednesday of last week, when a year of progress was reported. The report of the council shows that at the end of 1953 the total membership of the Institution was 1294, an increase of 188 during the year, a particularly pleasing factor being the rising number of overseas members. The growing importance of the National Diploma in Agricultural Engineering is emphasised in the report which states that twenty-four candidates sat for last year's examination. Fourteen were awarded the Diploma. During the year fifty-five candidates were awarded certificates following examinations held in connection with the Institution's farm machinery operatives' course. Mr. D. P. Ransome, M.I.Mech.E., was elected president of the Institution for a second year, and Mr. J. C. Gough has been elected a vice-president. Mr. W. J. Nolan has succeeded Mr. Gough as honorary treasurer. The meeting was followed by a luncheon attended by about 100 members and guests, with the president in the chair. The toast, "The Institution of British Agricultural Engineers," was proposed by Mr. B. W. Pendred, M.I.Mech.E., who said that the lineage of agricultural engineers must be very long indeed. He went on to speak of the lusty growth of the Institution, emphasising that one of the main objects of any learned society must be that of providing education. In company with civil engineers, chemical engineers, biologists and farmers, Mr. Pendred continued, it was the task of the Institution's members to increase the fruitfulness of the land and to raise the output of each man's labour. In his response to the toast, the president, Mr. Ransome, said that the Institution represented the standing of a profession which was not only national but international, and mentioned that requests were now coming forward for the National Diploma examinations to be held in overseas centres. He announced that the council had decided to establish a bronze medal in recognition of the valuable services rendered by Lieut.-Colonel Philip Johnson, a past-president and founder member of the Institution. The president stated also that Dr. Cornelius Davies, a past-president, had been elected to honorary life membership. Finally, Mr. Ransome paid tribute to the work of Mr. R. E. Slade, the secretary, and his staff, a tribute which was warmly endorsed by the company present.

## Lloyd's Register Shipbuilding Returns

THE shipbuilding returns for the quarter ended March 31st have been published this week by Lloyd's Register of Shipping. In Great Britain and Northern Ireland the work in hand totalled 323 steamships and motorships of 2,175,760 tons gross, of which eighty-six ships of 568,427 tons were fitting out, the remainder being still to be

launched. During the quarter sixty-five ships of 401,143 tons were commenced, fifty-one ships of 314,189 tons were launched and fifty-three ships of 403,613 tons were completed. Ships for registration abroad represented 27·6 per cent of the tonnage being built in this country. Oil tankers under construction totalled ninety-two ships of 1,116,998 tons, a decrease of 34,406 tons compared with the previous quarter, and representing 51·3 per cent of the total tonnage building. The volume of orders outstanding which has been falling at an average rate of 180,000 tons each quarter, dropped by 236,190 tons during the last quarter. Abroad the work in hand, excluding China, Poland and Russia, amounted to 814 ships of 3,991,242 tons gross, a decrease of 129,925 tons compared with the total at December last. Ships commenced during the quarter totalled 232 of 828,398 tons, being some 463,945 tons less than the previous quarter, while those launched and completed totalled 224 ships of 878,186 tons and 226 ships of 945,364 tons, respectively. The total of oil tankers under construction amounted to 207 ships of 2,325,643 tons, a decrease of 71,860 tons since December last, and representing 58·3 per cent of the total tonnage being built abroad. There were under construction throughout the world a total of 1137 steamships and motorships of 6,167,002 tons gross, being 127,874 tons less than the previous quarter. Of the total 35·3 per cent is being built in Great Britain and Northern Ireland. The ships building include ninety-eight of between 6000 and 8000 tons each, sixty-nine of between 8000 and 10,000 tons, 156 ships of between 10,000 and 15,000 tons, forty-eight of between 15,000 and 20,000 tons and forty-seven ships of between 20,000 and 30,000 tons each. A total of 299 oil tankers representing 3,442,641 tons, were under construction in the world, a total which is 106,266 tons less than in December and 55·8 per cent of the total tonnage building. In Great Britain and Northern Ireland 1,144,680 tons of steamships and 1,031,080 tons of motorships were under construction, the corresponding figures for building abroad being 1,987,262 tons and 2,003,980 tons. Of the world construction of steamships and motorships, at the end of March, 4,079,935 tons, or 66·2 per cent, are building under the inspection of Lloyd's Register.

## Books Received

*Manuel du Laboratorie Routier.* By R. Peltier. Paris: Dunod, 92, Rue Bonaparte, (VI$^e$). Price 2.600F.

*Alternating Currents.* Second edition. By L. T. Agger. London: Macmillan and Co., Ltd., St. Martin's Street, W.C.2. Price 8s. 6d.

*Introduction to Ultra-High-Frequency Radio Engineering.* By S. A. Knight. London: Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, W.C.2. Price 21s.

*Elementary Electrical Engineering.* Fourth edition. By A. E. Clayton and H. J. Shelley. London: Longmans, Green and Co., Ltd., 6 and 7, Clifford Street, W.1. Price 14s.

*Wege Zur Wirtschaftlichen Fertigung im Arbeitsmachinenbau.* By P. Lange and W. Rossberg. Germany: Verlag W. Girardet, Gerswidastrasse, 2, Essen. Price 28·80 D.M.

*Formulas for Stress and Strain.* Third edition. By R. J. Roark. London: McGraw-Hill Publishing Company, Ltd., McGraw-Hill House, 95, Farringdon Street, E.C.4. Price 53s. 6d.

*Textbook of the Materials of Engineering.* Eighth edition. By H. F. Moore and M. B. Moore. London: McGraw-Hill Publishing Company, Ltd., 95, Farringdon Street, E.C.4. Price 48s.

*A Manual of Time and Motion Study.* Fourth edition. By J. W. Hendry. London: Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, W.C.2. Price 15s.

*Select Methods of Metallurgical Analysis.* Second edition. By W. A. Naish, J. E. Clennell and V. S. Kingswood. London: Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 75s.

*Prestressed Concrete Design and Construction.* By F. Walley. London: Her Majesty's Stationery Office, York House, Kingsway, W.C.2. Price 30s.

*Modern Armature Construction, Winding and Repair.* By S. F. Philpott. London: Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, W.C.2. Price 30s.

# Institution of Naval Architects

## ANNUAL SPRING MEETING

No. III—(*Continued from page 611, April 23rd*)

THE meeting was continued on Thursday afternoon, April 8th, with a paper :—

### CORRUGATION OF BOTTOM SHELL PLATING

By J. M. MURRAY, M.B.E., B.Sc.

SUMMARY

This paper deals with the corrugation of the bottom shell plating and states that this form of failure has become extremely common in ships having transversely framed bottoms of welded construction and that part welded and riveted ships have been affected but to a lesser extent. After touching upon the extent of the phenomenon the paper goes on to describe the mechanism of corrugation and to list certain consistencies which have been established from an examination of records of corrugations. Theoretical considerations are discussed next and a method of approach to the problem is suggested. To study the effect of compression on a full-scale model of a double bottom tests were carried out on specimens of both riveted and welded construction and particulars of these tests are given and illustrated graphically. In the next section of the paper the effect of corrugations as developed in service on longitudinal strength is examined together with results obtained by introducing longitudinal framing, the adoption of which is recommended for new ships.

DISCUSSION

The Chairman: In the hope that my remark will stimulate discussion, I want particularly to say, on item (3) of the author's conclusions—" The only structural means of eliminating this species of failure in welded ships is the introduction of longitudinal framing in the bottom "—that the R.C.N.C., on behalf of the Admiralty, realised this lesson perhaps thirty years ago.

Mr. J. Hodgson: This paper is of theoretical interest and of practical importance in relation to both the general and structural design of modern cargo ships. It is this aspect of the paper to which I would particularly draw attention. It must be admitted that thermal contraction in welds is inevitable and some unfairness or initial deflection in welded panels of plating between stiffening members is unavoidable, and if those members are rigid the deflections are likely to be significant. It was not suspected originally that these small deflections in the bottoms of these ships would seriously impair the structural efficiency of the plating acting as the bottom flange of the ship girder. Service experience over several years has shown, however, that the buckling strength of bottom plating so deflected is insufficient to withstand the compressive stresses experienced. Our experience in Lloyd's Register is in itself almost sufficient to confirm most of the author's conclusions. The paper explains the mechanism and the chief characteristics of service behaviour. The examples in Fig. 15 of the paper illustrate the observed facts, how the deflections grow after a number of years of service. As confirmed by experience, the riveted panel may be expected to remain completely stable and efficient up to a higher compressive stress than in the case of the initially deflected welded panel. This is an important point. But the modern cargo ship of all-riveted construction does experience compressive stresses in the bottom high enough to buckle the plating. This factor of service stress is of primary importance and its practical implications need to be emphasised.

Mr. R. B. Shepheard, in his paper on " Ship Structures," read before the Institution in 1951, dealt with the increase in hogging bending moments due to changes in design from the old poop, bridge and forecastle coal-burning type to the modern shelter deck oil-burner of higher speed. He pointed out that in the old ship the sagging moment in the unvarying ballast condition was the most critical, while in the modern ship the hogging moments in the variable loaded condition are now the governing consideration. In modern designs with high speeds the hogging stresses in the homogeneously loaded condition can be excessive. Long machinery spaces, fine form and often the provision of cargo space at the ends in long forecastles or poops have increased the hogging moments and stresses on the ships, and it has become necessary to give careful consideration to the disposition of the cargo, fuel and water carrying spaces to minimise hogging moments and stresses in the loaded condition and avoid the necessity of an increase in the scantlings of the ships. If the design stress in the homogeneously loaded condition is high, greater care is necessary in the loading of these ships when carrying heavy cargoes, to avoid undue weight being loaded in the foremost and aftermost spaces. That is clearly illustrated by the comparative stress figures given in Appendix I. They show that with a cargo of phosphates it is possible to vary the probable compressive stress in the bottom from 2·5 to 6·5 tons per square inch by different distributions of that cargo.

With regard to the structural design, I emphasise what the chairman has said and I think that to eliminate the type of defect investigated in this paper the only solution is to fit longitudinal framing in the bottom. To fit subsidiary longitudinal stiffeners as panel breakers in conjunction with the transverse system is structurally less efficient and probably not so economical as the straightforward longitudinal framing for new ships.

Mr. H. J. Adams: The author states that the transverse frame ship of all-welded construction is inherently liable to corrugations of the outer plating. We have been told that, due to the welding of the floors, the plating is dished up to some extent; and increase of the corrugation takes place later due to sea stresses. I believe that even if we devise a method of welding the bottom without any dishing up, we will still get corrugations in this type of construction. It is not the dishing up which is the important factor; it is the fact that the bottom is all-welded. There are many examples of ships which have appeared to be perfectly fair on the stocks, but when docked a few months afterwards have been found to have considerable corrugations.

Another point is the importance of corrugations. If they are isolated and are not deep they are probably not of great importance, but they require to be watched in order that they do not develop a dangerous pattern, such as a line across the bottom. The author mentions that at the end of the engine-room the corrugations are often rather excessive. This also occurs in line with the end of the long deck house, particularly if there is a hatch just forward of it. A corrugation can occur in small vessels where the end of the poop and the end of the engine-room coincide, particularly if the engine-room has a double bottom and the remainder of the ship has a single bottom. Some of it is due to the break in the strength

of the ship at those points and this corrugation and discontinuity usually results in a line of corrugations across the ship.

If anyone has any doubt as to whether it is necessary to stiffen a particular ship which has corrugated he might remember that we see the corrugations only when the ship is in dock, when the stresses are relatively low —if we could see the corrugations when the ship was on the crest of a hogging wave we should be shocked.

Curves are given in Figs. 17 and 14 of the paper, and you will see that if the $p$ value is 0·15 at a nominal stress of 5 tons per square inch, the efficiency of the panel is reduced by only about 4 per cent. Turning to Fig. 14, it means that the efficiency of the ship at the deck is practically unchanged, and at the bottom it is reduced by about 4 per cent. If the $p$ value is 0·2, the efficiency of the panel is reduced to about 55 per cent, the strength of the ship at the deck is reduced to about 96 per cent and at the bottom to about 80 per cent. Yet that is a very small deflection, and no doubt if it were increased to the values that we really get in ships, the strength would very quickly become seriously reduced.

Mr. L. G. Stevens : The crucial point in the theoretical considerations of this paper appears to be the determination of the degree of constraint at the edges of the panels. The author sets out to do this, but the method used does not seem to be sufficiently independent of the result it is attempting to explain ; it is so much tied up with the actual experience that I wonder whether or not it is a description of what has happened rather than an explanation of why it happened.

In Section IV, under the sub-heading " Application to a Specific Ship," the author uses the altered edge restraint on unloading, following compressive stressing, to explain why a second application of the same compressive stress will cause greater deflection than it did on the previous application. This I cannot understand, unless there has been some inelastic behaviour in the unloading and restraining cycle. This might occur if the tension following the compression cycle were of sufficient magnitude to increase the permanent set. It is doubtful whether tension of sufficient magnitude would often be encountered, though effects might be accentuated by redistribution of stress between adjacent panels due to the deflection of the floors. Unless something of this kind occurs the residual stresses on unloading would be such as to ensure that on reloading (elastically) to the previous value exactly the same deflection would occur and further yielding would be experienced only if the load were increased.

In this connection I wonder whether the statements in paragraphs ($f$) and ($g$), under the heading " Mechanism of Corrugation " in Section I have some significance. In ($f$) the author states that " The pattern of corrugations, in its initial stages, alters while the ship is in service ; later, when deeper corrugations develop, it tends to become more or less fixed, though there are on occasions instances of instability when the corrugations become large." In ($g$) he states that " The corrugations do not develop at a constant rate ; they may grow to quite an important size and then remain unchanged for as long as twelve months." Might the growth of the corrugations after a period of relative constancy be associated with some particularly heavy weather conditions in which tension in the stress cycle causes further yield ?

Mr. J. B. Caldwell : If we consider the welded ship as in Fig. 15 of the paper, with an initial deflection of $p=0·1$, when the nominal stress in the ship's bottom is 6 tons per square inch the maximum bending stress on the plating is 20 tons per square inch. We then assume that the yield stress has been exceeded at some point in the plate and that the subsequent permanent deflection is of the order of 0·2 of the plate thickness ; and the plate stress is defined by curve ($b$). Now consider what happens if the ship is again stressed to 6 tons per square inch in the bottom. The extrapolation of curve ($b$) gives a stress of the order of 40 tons per square inch. That, I think, is stretching the argument too far.

I think there are reasons for this rather alarming conclusion, and that this theory tends to overlook one aspect of the bending of a ship's bottom which may have some influence on the formation of corrugations. When the ship sags the floors approach each other by a given amount and when the ship is unloaded, the floors separate to their original distance ; then it is loaded again to a stress which brings the floors together again by the same amount as before. Whatever has happened to the deflected plating during loading and unloading and reloading, I find it difficult to see how the situation at the end of the first loading can be very different from that at the end of the second loading. So that the stresses that we would expect seem to over-estimate the situation. I think the root of the matter is that on unloading, if the deflected plating has been over-strained during the original compression cycle, when the floors return to their original distance apart there must be some overall tension in the plating which will reduce the maximum deflection.

Professor Ir. H. E. Jaeger : I have worked in this field for a long time and there was a preliminary report by the Netherlands Shipbuilding Research Association in 1951. The Dutch shipbuilders became anxious about this waviness in the bottom structure and the Research Association asked me to try to give an answer. We concluded that on a very simple theoretical basis the stress in the bottom plating due to the initial deflection can be represented in a very simple formula.

Professor E. V. Telfer : In shipbuilding we have very poor memories. The conclusion in Mr. Murray's paper that the framing should be longitudinal in the bottom was anticipated a hundred years ago this year in the " Great Eastern." The historical note is what I want to stress. Here we are in 1954 trying to prevent the bottoms of ships buckling. I think it is very late in the day, and I would like to go to the first cause of what, in my opinion, eventually produces the buckling of ships. I think it was only as far back as 1916 when the section modulus was first introduced into shipbuilding work officially by the Freeboard Commission. As the result of the work of the Commission, two types of ships became popular ; one was the full scantling ship and the other the complete superstructure ship. Those who became modulus minded realised that the old-fashioned ship had a very asymmetrical position of the neutral axis, and it was thought right to raise up the neutral axis and get a much better and much more efficient section. That has been done. We have allowed the pure geometry of section modulus to change our ideas of ship construction. We have thinned down the bottom plating of the ship much more than in the full scantling vessel. The bottom structure has a dual duty to perform. That is what we are suffering from now ; and if it were known a hundred years ago, it is now about time that it was more appreciated.

Mr. L. Woollard : I want to say how thoroughly I endorse what our chairman said at the beginning, that for a long time in the warship world we have appreciated that the advantage of continuous and closely spaced longitudinal framing is that the panel stress in the plating is much smaller than with transverse framing. With the latter the trouble in welded ships is probably due to the bottom no longer being stiffened by laps, as is the case with riveted ships.

The Thursday afternoon meeting was continued with the reading of :—

## THE APPLICATION OF WAVE RESISTANCE CALCULATIONS TO SHIP HULL DESIGN.

By A. Emerson, M.Sc.


### Summary

The method of obtaining a hull form to satisfy specific requirements is described as being empirical and it is suggested that the study of ship resistance will be placed on a firmer basis if satisfactory empirical corrections to the idealised solution can be found. A statement of the problem is given and the paper declares that the model wave resistance obtained by subtracting the skin frictional resistance from the total measured resistance is inaccurate since the wave resistance is small at low speeds and at high speeds the shape of the underwater hull due to trim and sinkage is different from that of the hull at rest. Empirical corrections are reviewed and this is followed by a discussion on the correction factors and an example of the application of corrections. A comparison of measured and calculated wave-making resistance is shown graphically and also the results of a wave resistance calculation made for the " Lucy Ashton."


### Discussion

Professor Sir Thomas H. Havelock, F.R.S. : Mr. Emerson has made a useful attempt to make up for the deficiencies of wave theory so that it may be used practically in ship design. I agree that for this purpose it is necessary to supplement the usual theory by introducing empirical correction factors. I think there are three conditions for the use of such factors : (1) the basic theory should be good enough for the necessary corrections to be relatively small ; (2) the definition and application of the factors should be based on reasonable assumptions ; (3) the corrected results should give the right answer.

I wish to make one or two remarks under the second of these conditions. Mr. Emerson uses two factors, $\alpha$, $\beta$, introduced into the resistance, as in the section of the paper headed " Empirical Corrections." The $\beta$ factor is clearly associated with boundary layer effect on the stern wave system. We may think of it as a reduction in the amplitude of the stern waves and as the resistance involves the square of the resultant wave amplitude, we get the three terms as in the section mentioned. The value 0·95 taken for $\beta$ seems rather high, and perhaps Mr. Emerson would expand his reasons for this value.

I find the $\alpha$ factor more difficult. If the boundary layer effect has been properly accounted for by the $\beta$ factor, I do not think there is much left for further viscous effects ; the mere damping of the waves by ordinary viscosity must be quite small. I agree with Mr. Emerson in regarding the $\alpha$ factor as a more general correction, probably associated with the effect of finite beam. It might be called a screening factor ; the body of the ship screens the stern from the full effect of the bow waves. The introduction of this factor into the resistance is not so obvious as for the $\beta$ factor. On the present view we might expect some increase of amplitude at the bow as well as a reduction of the bow waves at the stern. However, the interference effect is probably the most important part, and Mr. Emerson allows for this by

simply having a factor $\alpha$ in the corresponding term in the resistance.

As shown in the paper, this general idea of the function of this factor is borne out by its diminishing value with increasing beam, or again by its small value for a model with the full end leading. One would expect $\alpha$ to be small at low speeds, that is, when the wave length is small compared with the model length. Mr. Emerson remarks in his discussion of correction factors, that for lower speeds $\alpha$ could be reduced, but it would no longer have a physical meaning. I do not follow this argument.

Mr. H. G. Hogben : At present the correlation of measured and calculated results is the most important but least satisfactory aspect of wave-making research, and it is very reassuring to find that Mr. Emerson seems to bring theory and practice so closely into line. I have regarded the $\alpha$ factor as being related physically to the viscous damping of the bow wave as it moves aft. If we assume the damping out of the bow wave as it comes aft, Mr. Emerson points out that a difficulty arises at lower speed, where you get a large number of effects in the length of the ship. The trouble seems to be that the $\alpha$ factor does not envisage a gradual dying out of the amplitude of the wave, but that we get a sudden change at midships to more amplitude. Can we develop some law in introducing the calculation ? This would complicate the analysis, but it may be of interest.

Professor J. Weinblum : The author states in his concluding remarks that the present reliance on model testing alone makes for slow progress and is inherently dangerous. I agree with that statement. But Fig. 1 in the paper indicates the shortcomings of the present hydrodynamic theory. Using his resistance coefficient, the calculated curves coincide for a given ratio of draught/length. So that the weakness of our knowledge in the field of ship resistance is apparently thoroughly demonstrated !

None the less, I agree with the author's remark as to the use of the theoretical approach. I think the present series presents an indispensable working hypothesis when discussing resistance properties and developing ideas as to the direction in which changes in the ship form should be made in order to improve its qualities.

The activation of Mr. Wigley's semi-empirical formula by the author appears to be successful. May I refer to the Taylor Model Basin work which permits of an almost immediate evaluation of Michell's integral for simple hull form ?

Professor L. C. Burrill : Fig. 1 in the paper has revealed something which I had not appreciated. Many have feared to tackle the mathematical calculation of ship wave resistance and some of us have not realised that the curves published previously have concealed to some extent the marked discrepancies which exist between the calculated values and those which are obtained from models. I am entirely in favour of the pursuit of mathematical excursions, and would not ask the mathematicians necessarily to give us proper and accurate solutions. At the same time, when we are going to use the mathematical approach for testing or checking practical results we must be satisfied that, by whatever means we adopt, we do get near the right answer. I support strongly this approach to semi-empiricism whereby an arbitrary correction factor is introduced. It would appear that this will produce from a mathematical calculation something like a physical result.

Mr. B. J. L. Hall : Speakers have mentioned that, from Fig. 1, apparently the calculated values for wave resistance do not vary as the square of the beam. I think we should realise that this variation of resistance with beam is not always so simple ; and when we are considering fairly full forms that may be very important. I would like Mr. Emerson to amplify this question of 5 per cent virtual lengthening of the form. Obviously the effect of viscosity must be to prevent the streamlines from fairing in in the same way as they would if there were no viscosity, and this will obviously result in the lengthening of the form. Also it must result in the filling out of the end of the form.

Mr. W. C. S. Wigley : Taking the equation quoted in the section headed " Empirical Corrections," as there were two arbitrary constants I assumed they were to be used singly, because of the complication involved if one used them both. Mr. Emerson has gone a stage further and it is an advance when we note how nearly we can get to the right answer with that change. There are a number of theoretical objections to the whole procedure but the answer seems to come out all right.

Mr. J. R. Shearer : It is interesting that in the field of aerodynamics the application of the theoretical approach to the design of aerofoils has given drags substantially lower than were ever obtained by empirical means, and I feel very much that we may reach the same stage in this field. I have a feeling that a full form has a tendency to concentrate areas of wave-making, that the lengths where the waves are generated are rather concentrated. It may be that the influence of viscosity is less. I would like to know what the author thinks about it.

Professor E. V. Telfer : In connection with Fig. 1, Mr. Emerson states that he has adopted a special presentation of the resistance. The only thing I can see that is special is that it is not non-dimensional. With regard to Fig. 2, you will notice that the values given are of wave-making resistance, $C_w$, corrected for beam. I do not understand that, and it is particularly confusing because you will see that model 825, which has the highest resistance, has the least beam ; in fact, the wave-making resistances vary inversely as the beam, and certainly not as the square of the beam, as Mr. Hall has rightly pointed out. For some reason the relation here is completely reversed. That may be due to another point, that the whole of the correlation work involved in the paper depends on the particular frictional resistance value which Mr. Emerson has been forced to adopt. You can get this particular effect with very slim models ; if the specific frictional resistance does increase as the equivalent length/depth ratio of the model, then additional skin friction appears in the slimmer model. That may be the explanation. It seems to be the explanation of Figs. 5 and 6 in the paper, where the Taylor comparison is reviewed. There it is based on quite a high specific resistance. The original Taylor specific resistance has a value of about 2·83. If you calculate the possible range of specific resistance due to the range of length/depth ratio of the model, it varies from about 2·89 down to 2·7 for the infinite area form. The effect of that you will see in the diagrams by the prediction of the very slim models being too low and the prediction of the very fat models being too high. That seems completely in harmony with the variable specific resistance being a function of the length/depth ratio of the model.

*(To be continued)*

# Compound Diesel Engines for Aircraft

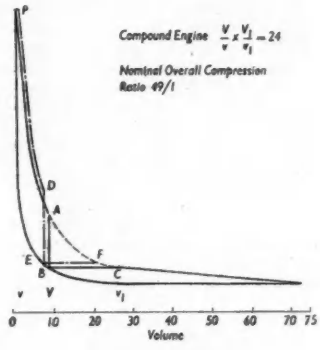
By E. E. CHATTERTON, B.Sc. (Eng.), A.M.I.Mech.E., F.R.Ae.S.*

*In this abstract from a paper read before the Royal Aeronautical Society on Thursday, April 22nd, the author discusses some thermodynamic and mechanical aspects of compounding a gas turbine with a reciprocating internal combustion engine and explains the superiority of the diesel engine in such an arrangement.*

## Derivation of the Compound Cycle

*The Spark Ignition Engine.*—The petrol burning engine, by its nature, consumes essentially all the air supplied to it and the power developed by a given size of cylinder is almost entirely dependent on the rate at which it can inhale and reject air. Apart from changes in operational speed, the air quantity can be increased by supercharging but the extent to which this is possible is limited by detonation and pre-ignition difficulties.

Combustion takes place at constant volume and the peak temperature of the cycle will be in the region of 2500 deg. Cent. Basically the thermal efficiency of the cycle is governed by the




**Compound Cycle**

volumetric ratio $V/v$ and this again is limited by the occurrence of detonation. Furthermore, if the supercharging pressure is increased to raise the maximum power, the compression and expansion ratios will, in general, require to be reduced to avoid detonation with consequent sacrifices in thermal efficiency over the cruising range of the engine.

It is therefore true to say that the destructive phenomenon of detonation is the limiting factor to both the power output and the thermal efficiency obtainable from this type of engine and most of the spectacular power development demonstrated during the 1939–45 War resulted directly from the introduction of fuels less prone to detonation, coupled with the use of water injection and charge coolers which allowed the charge density to be increased and its temperature reduced, thus keeping within the detonation limits.

This type of engine is not amenable to manipulation of its cycle for compounding purposes for any back pressure imposed in the exhaust system by a turbine will introduce practical difficulties, such as an increase in temperature of exhaust valves, and an increase in the mass and temperature of the residual gases which reduces the volumetric efficiency and raises the charge temperature, thus accentuating the already acute detonation difficulties. The best that can be done with this cycle is the arrangement already referred to as used in the turbo-cyclone in which a proportion of exhaust heat recovery is achieved without disturbance to the normal pressure and temperature levels in the engine cylinder.

*The Diesel Engine.*—This engine also attempts to burn all the air which is supplied to it, but as in this case the mixing of fuel with the air has to take place in the cylinder within a maximum period of about 35 to 40 degrees of crank rotation it is not found possible in practice to utilise more than about 80 per cent of the total air trapped in the combustion chamber. For a

* Chief Engineer, Piston Engine Division, D. Napier and Son, Ltd.

given maximum power output the cylinder dimensions will therefore need to be larger than in the spark ignition engine. In the two-stroke diesel engine a further loss of air occurs because of the necessity for effectively scavenging the burned gases from the cylinder, which implies a wastage of about 40 per cent of the total air throughput which will escape from the exhaust ports or valves during the scavenging process. This air lost during scavenging is not entirely without value for it does act as an internal cooling agent and therefore reduces the thermal loadings on the pistons for a given amount of fuel burned.

As with the petrol engine, the quantity of air trapped in the engine cylinders can be increased by supercharging and, as the detonation limitation no longer exists, the degree of supercharge can be increased as dictated by the general balance of the engine design. It will be observed, however, that in the two-stroke engine any degree of supercharge can only be effective providing that a corresponding resistance, or back pressure, is offered at the exhaust ports or valves.

Combustion takes place partly at constant volume and partly at constant pressure, the proportion of fuel burned at constant volume being to some extent controllable and determined by the limitation established by the designer for the maximum cylinder pressure.

Although not strictly correct, due to the portion of constant pressure combustion, the thermal efficiency for present purposes may again be related to the expansion ratio $V/v$, which in this case is considerably higher than in the petrol engine case with resultant improvement in fuel consumption.

The flame temperature during combustion will also be in the region of 2500 deg. Cent. but, due to defective air utilisation, the heat of combustion is diluted to some extent and the maximum temperature spread over the total air in the combustion chamber will be reduced to about 1800 deg. Cent.

It will be apparent that the cycle of operations described, particularly when referred to the two-stroke engine, is very much more adaptable for compounding purposes than the spark ignition case, for the following possible variables exist :—

(*a*) In the absence of detonation or pre-ignition troubles the compression ratio and the degree of supercharge may be varied to suit design requirements.

(*b*) The maximum cylinder pressures are to some extent controllable by variation in the rate of fuel input.

(*c*) Back pressures in the exhaust system need not be an embarrassment and are in fact essential when high degrees of supercharge are to be used.

(*d*) An excess quantity of air, over and above that required for combustion is passed through the engine, this serving as an internal cooling agent which also reduces the mean temperature of the exhaust gases.

It will be seen later that these possibilities may be turned to very good account in the compound engine and it may be stated here that the two-stroke diesel cycle forms the ideal basis for compounding.

*The Gas Turbine.*—Discussion here is limited to the propeller-turbine engine as it is this arrangement which is of interest relative to the compound case. Combustion takes place at constant pressure and the basic thermal efficiency is again governed by the volumetric expansion ratio which, in the present state of compressor and turbine development, is limited to a lower value than that employed in either the diesel or the spark ignition motor. If such an engine burned all the air passed through it the temperature of combustion would again be in the region of 2500 deg. Cent. and this is the continuously maintained temperature at which gases would enter the turbine. This temperature is prohibitive and with available materials and design technique, the temperature at the inlet to the turbine is limited to about 1100 deg. K. To achieve this reduction in temperature, air to the extent of about three-and-a-half times the amount actually required for combustion is therefore passed through the engine to provide temperature dilution.

When such an arrangement is associated with a piston engine to form a compound system such high excess air factors become unnecessary, for the reduction in gas temperatures is achieved by virtue of the work done in the piston engine cylinders and the compressor and turbine dimensions for a given rate of fuel consumed are thereby greatly reduced.

## The Compound Engine

In the compound engine the cycle of operations is shared between a two-stroke diesel engine and a turbine, exhaust gases from the engine being fed into the turbine. The back pressure imposed by the turbine on the engine cylinders establishes the lower pressure level of the operating cycle in the cylinders and also determines the degree of supercharge necessary to pass the required quantity of air through the engine.

The approximate form of the overall indicator diagram resulting from this combination is shown in the diagram, the division of work between the engine and the turbine being indicated by the line *ABC*, the difference in pressures between points *A* and *B* being that which exists between the pressure in the cylinder at the moment of exhaust release and the pressure at the inlet of the turbine.

Considering first the characteristics of this complete diagram, it may be said that due to the high degree of compression which takes place outside the engine cylinders it is possible to use an overall compression ratio considerably higher than in the normal diesel engine. Furthermore, the expansion line in the turbine extends down to atmospheric pressure and the result of these two factors combined is to produce a very high value for the overall expansion ratio. The actual expansion ratio which determines the limiting thermal efficiency, however, is lower than this due to the losses which occur at transfer from the diesel engine to the turbine and its value may be derived in the following way.

It will be seen that the overall diagram is compounded of two separate ones, first that for the diesel engine and, second, that for the compressor-turbine combination. The expansion ratio for the diesel cycle is $V/v$, and that for the turbine $V_1/v_1$, so that the actual expansion ratio for the complete cycle is given by the product $(V/v)\times(V_1/v_1)$.

Within practical limits, for a given overall diagram the value of expansion ratio given by the product $(V/v)\times(V_1/v_1)$ and therefore the limiting thermal efficiency of the cycle, does not change materially with the position of line *ABC* indicating the division of work between the diesel engine and the turbine.

But the division of work does exercise considerable influence on the dimensions and weight of the combined unit for a given maximum power and the selection of the various design constants affecting this point is one of the major problems in the early stages of compound engine design. Some indications of the nature of this problem may be obtained from a consideration of the following points.

Clearly the compound engine is subject to the same practical limitations as apply to other engines, so that the maximum cylinder pressure and the maximum turbine inlet temperature are reasonably well defined points determined by practice. If now the compound engine operated on an ideal air/fuel ratio and burned all its air, the temperature at point *P* would be about 2500 deg. Cent. and corresponding temperatures at various points down the expansion line would be defined. The maximum height for point *C* on the expansion line would therefore be fixed by the permissible turbine inlet temperature and this would also establish the supercharging pressure.

But it has been already pointed out that the diesel engine does not consume all the air supplied to it and furthermore, that in the two-stroke cycle the excess air passed through the cylinders during the scavenging period can be controlled by porting design.

It is therefore possible to design the cycle so that the amount of excess air is a relatively high proportion of the total mass flow through the engine, in other words, to operate the engine on a higher overall air/fuel ratio. This excess air will mix with the exhaust gases and reduce their temperature so that to achieve the same limiting temperature at inlet to the turbine it now becomes possible to raise the position of point *C* on the expansion line to a new position *F*, the division of work now being indicated by line *D*, *E*, *F*. But this adjustment to the cycle has also raised the supercharging pressure, so that a greater quantity of air will be trapped in the engine cylinder thus permitting more fuel to be burned and a greater mean indicated pressure to be developed, as shown by the dotted expansion line.

The thermal loadings in the engine cylinders will set a limit to the extent of this adjustment but, as a practical point, it may be said that the passage of excess air through the cylinders not only gives ideal scavenging, it also provides a considerable degree of internal cooling, any resulting increase in its temperature being subsequently recovered in the turbine and therefore retained in the cycle. By exploiting this factor it is possible in the compound engine cylinder to achieve a rate of fuel burning which is much greater than in the normal diesel engine, with a corresponding reduction in the dimensions and weight of engine required for a given power. This, coupled with the reduced size of compressor and turbine required for a given rate of fuel burning, allows the size and specific weight of the compound power plant to be reduced to values which, when coupled with its high thermal efficiency, render it more suitable than other power plants for certain applications.

The determination of the appropriate division of work in any particular case, therefore, involves consideration of a range of different overall air/fuel ratios, each involving corresponding adjustments to the size and pressure ratio of the compressor and turbine and the dimensions of the engine cylinders derived from the thermal and mechanical loadings imposed. The lightest possible power plant results when the best balance between these various factors is established in relation to the design targets.

Some characteristics of the compound engine as demonstrated by the " Nomad " are given in the table to allow comparison with other types of engine.

Table I—*Comparative Performance of Piston Engines*

| Type of engine | Actual engine | Fuel | Max. s.h.p. at take off | Max. s.h.p. per litre | Max. s.h.p. per square inch of piston area | Specific weight lb per s.h.p. at take off | Specific fuel consumption, lb per s.h.p. per hour. Sea level at 60 per cent T.O. power |
|---|---|---|---|---|---|---|---|
| Petrol engines | Napier " Sabre VA " | 100/130 grade | 2550 | 69·5 | 5·43 | 0·976 | 0·50 |
| | Napier " Sabre VII " | 100/130 grade | 3050 | 83·2 | 6·5 | 0·840 | 0·50 |
| | *Wright Compound | 115/145 grade + water | 3700 | 67·3 | 6·97 | 0·92 | 0·400† |
| Two-stroke diesel | Junkers " Jumo 205E " | Diesel fuel injection | 600 | 36·0 | 3·73 | 1·910 | 0·345 |
| | Napier " Nomad " | Diesel fuel | 3046 | 74·2 | 9·0 | 1·175 | 0·359 |
| Compound * diesel | Napier " Nomad " | Diesel fuel + water injection | 3480 | 84·8 | 10·25 | 1·027 | 0·345 |
| | Napier " Nomad " | Diesel fuel + auxiliary combustion | 3970 | 96·5 | 11·70 | 0·959 | 0·340 |

* Figures based on total s.h.p.

† 51 per cent power—auto-lean mixture.

# 3·2MV Impulse Generator at the National Physical Laboratory

LAST week we attended a demonstration of the new Marx impulse generator which has been installed at the National Physical Laboratory, Teddington. This equipment is capable of generating an open-circuit test voltage of 3·2 million volts with a stored energy capacity of 77kW seconds, which should be adequate to meet requirements for some years to come.

It may be recalled that the N.P.L. has had a similar, but smaller, impulse testing apparatus for nearly twenty-five years. This generator, which was built by the N.P.L. staff, had an open-circuit voltage of 2,000,000V and a total stored energy of 20kW seconds—values which were amply sufficient, at least until the end of the war. More recently, however, it was evident that the

**Fig. 1—Eight-Stage 3·2MV Impulse Generator at the National Physical Laboratory**

equipment was becoming inadequate, partly because transmission voltages were continually rising—380kV is in use on the Continent and 275kV in Great Britain—and partly because some of the components were nearing the end of their useful life.

Accordingly it was decided to install a new impulse generator. Its size is limited only by the available laboratory space and, with its open-circuit voltage of 3·2 million volts and stored energy capacity of 77kW seconds, it is believed to be the largest surge generator in the country. Like its predecessor, this equipment is based on the familiar Marx circuit, in which a number of condensers are charged in parallel through high resistances from a d.c. source and are then automatically discharged by being connected in series by the breakdown of air gaps set to appropriate values.

The generator, as illustrated in Fig. 1, is an eight-stage arrangement with a maximum stage voltage of 400kV, which is derived from a transformer and voltage regulator, with a metal rectifier in a voltage-doubler circuit. This arrangement is designed to produce the 400kV required, with an adequate margin and with either positive or negative polarity. Each stage consists of two capacitors in separate porcelain housings, the total stage capacitance being 0·12 microfarad. The eight stages are assembled into a four-column structure, the capacitors of each column being spaced by porcelains similar to those which house the units themselves. The generator is provided with internal charging, discharging and damping resistors, while other resistors for discharge and damping are mounted externally. The interstage spark gaps have as electrodes spheres 50cm in diameter, and the spacing of the gaps can be adjusted in unison by a geared motor drive which is controlled from the operating desk, where an indicator shows the gap spacing. An external bank of capacitors constitutes a permanent capacitance load on the generator, and is the high-voltage section of a capacitance voltage divider for the measurement and recording of the generated surges.

This capacitance voltage divider can be seen in the background in Fig. 1 and at the bottom of Fig. 3, which shows a forty-five-element insulator chain being subjected to dry flashover. The upper end of this insulator chain is, of course, connected to the building at earth potential, while the lower end is at the full test voltage.

All the controls for the generator are centralised in a desk installed in a steel-framed, glass-fronted "blister" (Fig. 2), which projects into the main laboratory at the first floor level of the building. From the control desk the operator has a clear view of the whole laboratory. The controls include facilities for reversing the polarity of the test voltage, for earthing the equipment, for varying the charging voltage and for firing the generator to produce a voltage of predetermined amplitude and polarity.

Provision is made for the controlled electrical firing of the generator when it has been charged to the correct voltage and for tripping the high-speed cathode ray oscillographs before the generator is discharged, to give adequate time delays in preparation for recording, without the use of a long delay cable. For this triggering operation use is made of a "peaky" transformer and a pair of three-electrode gaps which can be seen at the base of the generator in Fig. 1. The required delay effect is produced by the introduction of a suitable *CR* combination in this part of the circuit. The settings of the three-electrode gaps can be varied independently of the main gaps.

The size of the generator and the value of its open-circuit voltage were limited by the required clearances to the walls and roof of the building. To make the best use of the available space it was necessary to mount the base of the generator at a depth of about 8ft below the normal floor level, and a pit was therefore excavated and suitably faced for this purpose as can be seen from Fig. 1. The minimum clearance to earth from the output end of the generator is 21ft. The metal rectifier and voltage-doubler can be seen in the foreground of Fig. 1. In the background are the large roller doors whereby heavy transformers, insulators and other plant can be brought into the laboratory for test. We understand that it is proposed shortly to carry out surge tests on a 275kV transformer for the British supergrid.

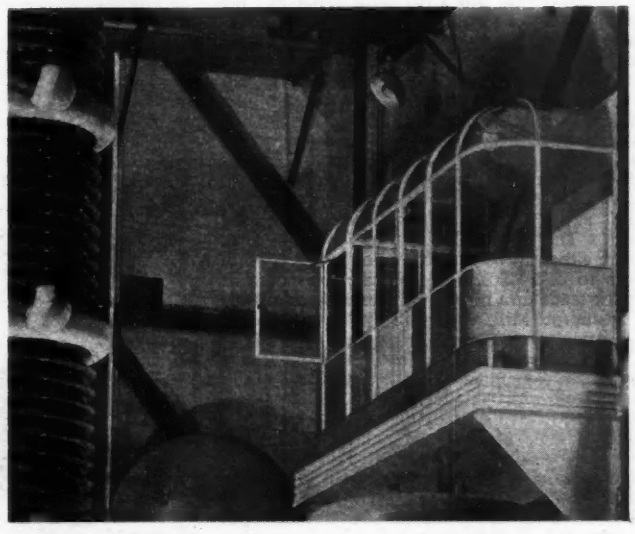


**Fig. 2—Control Room (right) and Part of the Impulse Generator (left)**

### Contractors

The installation of the impulse generator, including the civil engineering work and the auxiliary services, was carried out by the Ministry of Works in collaboration with the N.P.L. staff and with Ferranti, Ltd., of Hollinwood, Lancs, who supplied the generator. The capacitors used by Ferranti, Ltd., in the construction of the generator were supplied by British Insulated Callender's Cables, Ltd.

**Fig. 3—Flashover on a 45-Unit Insulator Chain**

## Tower Windmills in Lincolnshire

At a meeting of the Newcomen Society which was held in London on April 14th, the president, Mr. Rex Wailes, presented a paper dealing with tower windmills in Lincolnshire. He explained that the typical Lincolnshire tower mill had a white-painted ogee cap, a fantail and four patent sails set on a round brick tower. Many of these brick tower mills replaced earlier wooden mills, either smock or post mills, and many even replaced earlier brick tower mills. About 150 years ago there were, in addition to these new tower mills, hundreds of small smock mills used for the

**Trusthorpe Mill, Moved from Newland, Hull, in 1881**

draining of the Fens. These began to go out of use in the 1820s when steam pumps were installed, and the decline in the numbers of windmills in use, which started then, had continued steadily ever since. In 1923 there were at least eighty tower mills at work by wind in Lincolnshire and there had been many more at the turn of the century ; to-day there were but six, in a county which in size was the equivalent of three ordinary counties.

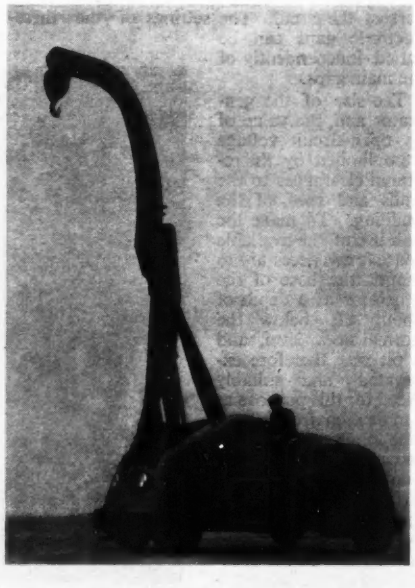
Mr. Wailes went on to say that the Lincolnshire tower mill had a red brick tower and the number of floors was four, five or seven in about equal proportions. About a dozen mills had six floors, half-a-dozen had eight, and at the extremes Friskney had three and Moulton had nine, making it the tallest mill in Lincolnshire. Heights, exclusive of the ball finial on the cap, varied from 30ft at Friskney to 75ft at Maud Foster Mill, Skirbeck and East Kirkby. Inside diameters ranged from 18ft at Wildmere to 28ft at Heckington, both of them tapering to 11ft at the curb, which was usually corbelled out. The brick towers, Mr. Wailes added, were either tarred or left red in a proportion of two to one. Some of the mills were built of brick made in a nearby field, one of these being Trusthorpe Mill, shown in the accompanying illustration.

The paper then described the boat-shaped and ogee caps fitted to Lincolnshire tower mills and dealt with winding gear and sail arrangement. Mr. Wailes said that he had seen only one example of rack and pinion striking-gear for patent sails. This was at Trusthorpe and even there a lever was used ; in all other cases operation was by rocking-lever. Some of the levers rocked above the horizontal centre line of the striking rod, others below it ; some were on its vertical centre line, others were offset. The connection to the striking rod varied from a block on the end of the rod running in channel guides, to two or even four wheels, plain or grooved, running on or between guides. A swinging safety catch, like a brake catch, was occasionally used to hold the striking lever in the " shutters open " position as at Addlethorpe, but more often a hinged block was dropped between the back of the tail bearing and the sliding block and sometimes this could be operated from the ground as at Scartho Mill. As extreme examples of the useful life of sails, two made from a pitch pine log washed upon the sea shore, were put on Addlethorpe Mill in 1882 ; one lasted ten years, the other was only removed in 1949.

Mr. Wailes gave also some details of windshafts—only eight of which were of wood in the mills he had visited—brake wheels, upright shafts, great spur wheels, stone nuts, and power drives for the mills. He concluded his paper with some references to millwrighting in Lincolnshire, remarking that there was now only one firm of millwrights undertaking repair work. The most interesting millwrighting jobs which had been carried out in the county were at Heckington and Trusthorpe. The former mill, eight-sailed, was known as Tuxford's Mill, Boston. In 1891 when Boston Docks were about to be constructed, the mill, standing on part of the site, was put up for sale and bought by Mr. John Pocklington for £100. He purchased a burnt-out tower at Heckington and transferred the cap, sails, fantail and the interior of the Boston Mill there, doing the work by direct labour and putting up the sails on successive Saturdays in the snow. The mill worked until his death in 1943 ; in 1953 it was repaired as a landmark by the Kesteven County Council and two sails each from Old Bolingbroke and Wainfleet Mills were fitted to it. Trusthorpe Mill was similarly moved from Newland, Hull, in 1881 by Charles Foster. He carried all the parts, including all internal woodwork, to Stone Ferry, loaded them on two billy boys, which he sailed round Trusthorpe and beached, while, as already mentioned, the tower was built of bricks made close at hand by Foster himself.

## Mobile Crane with Hydraulic Motors

The 4-ton mobile crane shown below is driven by a hydraulic motor coupled to the front wheels, and all the wheels are independently mounted so that the vehicle can "crab" sideways in addition to conventional directional movement. It is claimed to be the first of its kind. Its design followed a request to the Unicum Company by K.L.M. Airlines for a unit which could be employed in confined spaces and under the most unfavourable conditions to remove and install engines without causing delay in other maintenance work during overhaul. The crane was also to be suitable for use in loading and unloading as well as transporting pieces of cargo weighing up to 4 tons. A telescopic folding jib was stipulated with a lift of 20ft and the vehicle had to be small enough to pass under the maintenance chocks. The vehicle had also to rotate about its own axis and be able to travel sideways at a reasonable speed.



**Hydraulic Motors Enable this Crane to Turn about Its Own Axis or Move Sideways**

Because of its hydraulic prime movers, driving shafts differential, gearbox with friction coupling, as well as wheel axles are dispensed with. The vehicle has in fact no tooth gearing whatsoever.

The lift is also hydraulically operated from the hydro-motor, and folding and lowering of the jib are hydraulically controlled, the movable part of the jib being raised and lowered by the same cable as is used to shift the load.

The three pumps which provide the pressure for the whole hydraulic system are driven by a six-cylinder diesel engine. These three pumps act as " gears " for changing speed. The maximum speed is 6 m.p.h. and it is not reduced when going uphill, turning round or moving sideways.

The crane was developed in close co-operation with K.L.M. technicians. One difficulty was that the front wheels had to have a wider tread than the rear wheels, because the crane remains on the same spot when rotating about its own axis. To make it easier for the crane to turn with a load of 4 tons, the two front wheels are fitted with jacks, which relieve them of the pressure.

## Technical Reports

*An Atlas of End-Grain Photomicrographs for the Identification of Hardwoods. Forest Products Research Bulletin No.* 26. London: Her Majesty's Stationery Office, York House, Kingsway, W.C.2. Price 12s. 6d. —The Forest Products Research Laboratory recently produced, as its Bulletin No. 25, a " Lens Key for the Identification of Hardwoods," and this atlas gives further help in identifying the commercial hardwoods met with in the United Kingdom. It supplements the lens key by providing photomicrographs of the timbers dealt with in the previous Bulletin and enables users to verify their identifications by comparison with photographs of authentic specimens.

The photomicrographs are all at × 10 (linear) magnification. This is a higher magnification than that obtained with a hand lens rated at × 10 (area magnification), but it helps to ensure reproduction of a similar degree of detail to what can be discerned with such a lens by a trained observer.

The atlas can be used for identification in conjunction with the already published lens key or any other key or, alternatively, it can be used by itself to identify a timber by direct comparison with the photomicrographs. It also provides a ready means of checking that a timber is what it is reputed to be.

The arrangement of the photomicrographs is in alphabetical order of botanical families, and within each family according to the botanical names of the timbers. This is the same as the arrangement used for the anatomical descriptions in the lens key and is intended to facilitate cross reference between the two publications. The atlas includes a list of the diagnostic features to be seen on the end-grain together with references to photomicrographs which illustrate these characteristics. The bulletin is completed by an index to common and botanical names.

*Corrosion of Buried Copper and Ferrous Strip in Natural and Salted Soils* (Ref. V/T110). The British Electrical and Allied Industries Research Association, Dorking Road, Leatherhead, Surrey. Price 10s. 6d., —Earth electrodes usually take the form of buried copper or ferrous strips, plates, rods or pipes, and a method sometimes used to reduce the resistance of such earth electrodes is to treat the surrounding soil with common salt. The salting process may be applied once only, to reduce the resistance while the electrode is settling down, or alternatively the electrode may be resalted at, say, yearly intervals, to assist in retaining a low resistance in soil of high resistivity. However, there was reason to suspect that salting was harmful in that it accelerated the corrosion of the electrodes.

To investigate the general question of corrosion of earth electrodes, excluding the grosser forms of electrolytic corrosion, an extensive survey was made covering soils of different types, in which were buried specimens of different metals normally in use for earth electrodes. In each soil both salted and unsalted sites were used. The tests covered exposures up to twelve years.

# Rail Transport Wagon Shunting Machines

By J. G. LEE*

No. II—(*Concluded from page* 614, *April* 23*rd*)

*Nearly all British ports at which iron ore is imported use locomotives for shunting and hauling wagons. This article presents the advantages and disadvantages of other machines designed for this duty and estimates the relative numbers of these machines required, with their cost. Recommendations are made as to which of these machines are suited to working an iron ore wharf.*

## Duties

BROADLY speaking, the duties can be classified into two kinds :

(1) Shunting duties, which necessitate the movement of wagons on the wharf to facilitate maximum unloading rate, and (2) the combined duties of shunting wagons on the wharf and the hauling of loaded wagons to some convenient point away from the main unloading area for their removal by locomotives.

If it is desired to combine the shunting duties of the machine with the hauling of wagons, it will be necessary to compensate for the time the machine is engaged on hauling by ensuring there are sufficient wagons available to maintain continuous unloading and that full wagons can be removed and replaced by empties with a minimum of delay.

Whether a machine can be conveniently used for hauling depends on whether this machine can be spared from shunting duties at the wharf, and how far it can move the wagons in that time. Another factor is the availability of space for wagon storage.

## Number of Machines Required

From an economic point of view it is necessary to know how many machines of each kind are required to perform a given duty.

The number of machines required will vary depending on the unloading rate, whether the unloading equipment has any storage hoppers, the size of the wagons in which the ore has to be carried away, and the number of lines within the unloading area upon which wagons can be shunted. It will be seen, therefore, that the number of machines required cannot be calculated without a detailed knowledge of the layout and working of the port. On the other hand, relative numbers of different machines is probably not so greatly influenced.

For the purpose of this economic comparison the number of machines have been calculated on assumed figures which are as follows.

A single-berth wharf equipped with two 19-ton unloaders having a maximum unloading rate of 4000 tons per eight-hour (seven and a half hours working and half an hour for meals) shift, which is equivalent to 534 tons per working hour. The unloaders have storage hoppers capable of holding 260 tons of ore. The ore is unloaded into 27-ton wagons (average load 25 tons). Each unloader is served by one railway line, which, when it leaves the wharf, merges nto a single track leading to the weighbridge. Adjoining the weighbridge track are sidings for the storage of empty wagons. The maximum curve to be overcome has a radius of 16 chains (see Appendix II). The track is assumed to be level.

The method of working assumes that the shunting machine collects empty wagons from the sidings and takes them to the wharf where the wagons are filled with ore from the unloader hoppers. The wagons are then drawn to the weighbridge siding and left there. The machine collects a fresh set of empty wagons from the adjoining sidings and repeats the operation. The full wagons left at the weighbridge are weighed and taken away by another machine which also brings back empty wagons and places them in the sidings.

Table I gives the haulage capacity and speed of each machine from which the number of machines have been calculated.

If the distance between the wharf and the weighbridge is large (between $\frac{1}{4}$ and $\frac{1}{2}$ mile) the alternative methods of hauling the wagons are by locomotive or shunting tractor. The other machines, because of their slow speeds, small haulage capacity and number of machines required (see Table V) would not be suitable.

When working in a confined space the locomotive has no speed advantage over the shunting tractor. It has been assumed, therefore, that the time to fill each wagon and the time taken from delivering full wagons at the weighbridge to when the train is ready to start the return journey to the wharf after collecting empty wagons from the sidings is the same for either machine. The locomotive has the advantage in journey time between the wharf and the weighbridge, and in the number of wagons it can pull (see Table I). Working under these conditions the ratio of petrol or diesel shunting tractors to small diesel-mechanical locomotive is 2 to 1.

If we are considering shunting duties only, one diesel tractor will keep pace with the unloading rate. The number of other machines required to do the same work can be calculated if the same basic assumptions be used as before (see Table I). These work out as follows :—

| | |
|---|---|
| Small truck mover | 8 |
| Large truck mover | 2 |
| Shunting machine | 3 |
| Capstan | 2 |
| Petrol shunting tractor | 1 |
| 150 h.p. diesel-mechanical locomotive | 1 |

If a 350 h.p. locomotive be used under these conditions it will be working well below its rated efficiency.

## Costs

The tables which follow give approximately the operating costs per week for each machine. The author wishes to emphasise here that the results have been based on available information and may be considerably affected by the conditions of working :

The costs have been divided as follows :—

(1) Standing charges which are incurred whether the machine is in use or not.

(2) Operating costs per shift which are incurred only when the machines are in use.

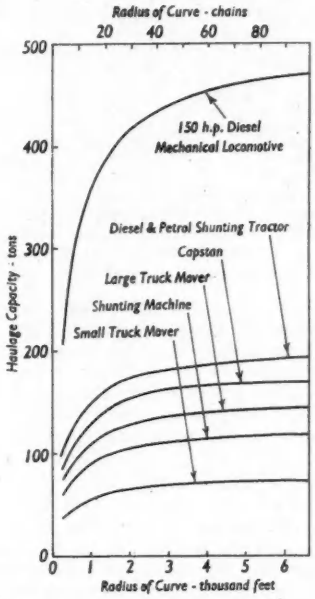



**Fig. 6—Effect of Track Curvature on Haulage Capacity**

Thus, knowing the shifts that are worked per week it is possible to calculate the operating costs per week. This, added to the weekly standing charges, gives the total cost per week for each machine.

*Standing Charges.*—Table II gives the standing charges for each machine. The figures are worked to the nearest pound.

Table I—*Haulage Capacity and Speeds of Machines*

| Machine | Capacity on straight, tons | No. of wagons on straight | No. of wagons on 16 chain radius curve | Speed | |
|---|---|---|---|---|---|
| | | | | Full wagons, m.p.h. | Empty wagons, m.p.h. |
| Small truck mover | 75 | 2 | 1 | 0·4 | 0·7 |
| Large truck mover | 150 | 4 | 3 | 2·0 | 3·0 |
| Shunting machine | 120 | 3 | 2 | 1·9 | 2·5 |
| Capstan | 175 | 5 | 4 | 0·9 | 1·4 |
| Petrol shunting tractor | 200 | 5 | 4 | 3·2 | 5·0 |
| Diesel shunting tractor | 200 | 5 | 4 | 3·2 | 5·0 |
| 150 h.p. diesel-mechanical locomotive | 500 | 14 | 10 | 6·0 | 10·0 |
| 300 h.p. or 350 h.p. diesel or steam locomotive | 1500 | 42 | 30 | 6·0 | 10·0 |

The capital cost of the machines takes into account the list price and any extras which are considered necessary for the proper running of the machine. For example, the cost of the capstan is only £486, but fairleads cost a further £19 each. It is estimated that at least two fairleads are necessary for each winch, and with a suitable length of wire the purchase price is increased by about £50. Installation charges have been taken as £50, thus making the capital cost of the capstan £586.

Where the road has to be built up to rail level before a machine can be used, the cost has not been included because this road would outlive one machine, and would serve more than one machine at a time. To include this expense in the life of one machine therefore would not be a true representation of its cost.

" Depreciation " has been based on the

* British Iron and Steel Research Association.

life of the machine assuming a nil scrap value.

" Interest " has been taken at 4 per cent.

" Maintenance " accounts for the general care of the machine, including recommended oil changes.

" Replacements " allows for tyres and engine wear.

*Operating Costs.*—Table III gives the operating costs per eight-hour shift (five hours worked) of each machine. The figures have been evaluated to the nearest shilling.

TABLE II—*Annual Standing Charges for Comparative Machines*

| Machine | Truck Mover | | Shunting machine | Capstan | Shunting tractor | | Locomotives | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Small | Large | | | Petrol | Diesel | 150 h.p. diesel-mechanical | 300 h.p. diesel-mechanical | 350 h.p. diesel-electric | Steam |
| Prime mover | Petrol | Petrol | Petrol | Electric | Petrol | Diesel | | | | |
| Costing life | 5 years | 10 years | 10 years | 10 years | 10 years | 10 years | 15 years | 30 years | 30 years | 50 years |
| Capital cost | £275 | £425 | £706 | £586 | £850 | £975 | £8,000 | £15,000 | £23,000 | £10,500 |
| Depreciation | £51 | £35 | £59 | £49 | £71 | £81 | £400 | £268 | £410 | £69 |
| Interest, 4 per cent | £11 | £18 | £29 | £24 | £34 | £39 | £320 | £600 | £920 | £420 |
| Maintenance | £69 | £78 | £99 | £10 | £99 | £99 | £600 | £800 | £800 | £715 |
| Replacements | £36 | £20 | £37 | £5 | £62 | £90 | — | — | — | — |
| Annual | £167 | £151 | £224 | £88 | £266 | £309 | £1,320 | £1,668 | £2,130 | £1,204 |

The fuel costs for all machines except the locomotives are based on the specified fuel consumptions and the current cost of fuel. The steam and diesel locomotive costs are those given by E. L. Diamond[1] and D. B. Hoseason[2] with a suitable estimated increase to allow for the increased cost of the fuel.

The lubricating oil includes topping up and the general lubrication of the bearings. The figures are taken from accumulated data from users' and manufacturers' specifications, and are costed at current rates.

The manufacturers of the truck movers, the shunting machine and the capstan claim that one semi-skilled man can operate these machines satisfactorily. It has been assumed, therefore, that one dock worker earning a basic wage of 3s. per hour operates these machines. The author, however, feels that two men, one to operate the machine and the other to control, couple and uncouple the wagons should be employed.

The shunting tractors will need an experienced driver and a shunter whose duties will be comparable to that of the locomotive driver and shunter. The combined wages of the driver and shunter have been taken as 7s. 8d. per hour for the tractors and the locomotives.

*Weekly Running Costs.*—Assuming an eleven-shift week a comparison of weekly running costs as shown in Table IV can be made. The figures have again been taken at the nearest pound.

TABLE III—*Operating Costs per 8-Hour Shift (5 Hours Worked) for Comparative Machines*

| Machine | Truck Mover | | Shunting machine | Capstan | Shunting tractor | | Locomotives | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Diesel-mechanical | | Diesel-electrical | Steam |
| | Small | Large | | | Petrol | Diesel | 100 h.p. | 500 h.p. | 350 h.p. | |
| Fuel | 8/– | 8/– | 8/– | 3/– | 20/– | 5/– | 8/– | 11/– | 11/– | 49/– |
| Lubricating oil | 1/– | 1/– | 1/– | — | 1/– | 1/– | 2/– | 2/– | 2/– | 1/– |
| Wages | 24/– | 24/– | 24/– | 24/– | 61/– | 61/– | 61/– | 61/– | 61/– | 61/– |
| Total | 33/– | 33/– | 33/– | 27/– | 82/– | 67/– | 71/– | 74/– | 74/– | 111/– |

Table IV clearly shows that the diesel shunting tractor is more economical to run than its counterpart in petrol.

The preceding chapter illustrates the number of machines required to maintain an unloading rate of 4000 tons per shift during shunting and hauling duties. The comparative costs of running these machines referred to the diesel shunting tractor are shown in Table V. The capstan has not been considered in the table for hauling since many more machines than required will have to be installed because of its limited range.

From the table it may be seen that the capstan is most suitable economically for shunting on the wharf under the given conditions. Should it not be practical to use the capstan for some reason the choice would be between the diesel shunting tractor and the large truck mover. Fatigue to the operator of the truck mover has not been taken into consideration in deriving these figures, and for this reason the shunting tractor is recommended.

For hauling duties the 150 h.p. diesel-mechanical locomotive appears to be best suited. As an alternative choice there is little to choose between the 300 h.p. diesel-mechanical locomotive, the 350 h.p. diesel-electric locomotive and the diesel shunting tractor. Although the steam locomotive and the large truck mover appear to be suited to this duty economically, the former gives way to its diesel counterpart on grounds of availability while fatigue to the operator of the truck mover has to be considered. A further drawback of the truck mover is the comparative number of machines required which will increase the demand for additional working tracks.

## CONCLUSIONS

As with all work of this nature where the result will vary depending on local conditions, it is impossible to state definitely that one shunting machine is superior to another. From the foregoing remarks, however, the following conclusions can be made when working an iron ore wharf :—

(1) The small truck mover, because of its slow speeds and poor haulage capacity, will not be suitable for either shunting or hauling duties.

(2) The large truck mover, although unsuitable for hauling duties, is suited to shunting duties, i.e. moving wagons on the wharf.

(3) The shunting machine is also not suited to hauling duties. As a shunting machine its merits are barred by its high price.

(4) The capstan economically appears to be the ideal machine for shunting. Its speed, haulage capacity and limited range go against it as a machine for haulage wagons.

(5) The petrol shunting tractor must give way to the diesel model for economic reasons.

TABLE V

| Machine | Shunting | | Hauling | |
|---|---|---|---|---|
| | No. req'd | Comp. cost | No. req'd | Comp. cost |
| Small truck mover | 8 | 4·0 | 25 | 6·1 |
| Large truck mover | 2 | 1·0 | 4 | 1·0 |
| Shunting machine | 3 | 1·5 | 6 | 1·5 |
| Capstan | 2 | 0·8 | Unsuitable | — |
| Petrol shunting tractor | 1 | 1·2 | 2 | 1·2 |
| Diesel shunting tractor | 1 | 1·0 | 2 | 1·0 |
| 150 h.p. diesel-mechanical locomotive | 1 | 1·5 | 1 | 0·7 |
| 300 h.p. diesel-mechanical locomotive | 1 | 1·7 | 1 | 0·9 |
| 350 h.p. diesel-electrical locomotive | 1 | 1·9 | 1 | 1·0 |
| Steam locomotive | 1 | 2·0 | 1 | 1·0 |

(6) The diesel shunting tractor appears to be the most versatile machine considered. Economically, it is surpassed only by the capstan as a shunting machine and for hauling duties can be considered as an alternative to the 150 h.p. diesel-mechanical locomotive.

TABLE IV—*Weekly Running Costs Assuming an Eleven-shift Week*

| Machine | Truck | Mover | Shunting machine | Capstan | Shunting tractor | | Locomotive | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Small | Large | | | Petrol | Diesel | Diesel-mechanical | | Diesel-electric | Steam |
| | | | | | | | 150 h.p. | 300 h.p. | 350 h.p. | |
| Standing charges | £3 | £3 | £4 | £2 | £5 | £6 | £25 | £32 | £41 | £23 |
| Operating costs | £18 | £18 | £18 | £15 | £45 | £37 | £39 | £41 | £41 | £61 |
| Running costs | £21 | £21 | £22 | £17 | £50 | £43 | £64 | £73 | £82 | £84 |

(7) The 150 h.p. diesel-mechanical locomotive economically appears to be the most suited machine for hauling duties. As a shunting machine it loses its advantage since it cannot work at its normal speed.

(8) The 300 h.p. diesel-mechanical locomotive is not suited to shunting duties since it works well below its designed efficiency. As a hauling machine it is second only to the 150 h.p. diesel-mechanical locomotive.

(9) The 350 h.p. diesel-electric locomotive is not suited to shunting duties for the same reason as the large diesel-mechanical locomotive. Economically, there is little difference between this type of locomotive and the large diesel-mechanical for heavy duties.

(10) The steam locomotive, because of its poor availability, gives way to the diesel locomotive of corresponding size.

## ACKNOWLEDGMENTS

The author would like to express his appreciation for the co-operation so cordially given to him in preparing the report by the manufacturers of the wagon moving equipment, the Railway Executive, the Port of London Authority and the Docks and Inland Waterways Executive. He also thanks the authorities concerned for the permission to reproduce the illustrations included in this report.

## APPENDIX I : GENERAL DETAILS OF MACHINES

The general details of the machines considered are as follows :—

(a) *Petrol-Driven Truck Mover*

Small model :

Speeds of operation :

First gear ... 0·35 m.p.h. (30ft per min)

Second gear ... 0·7 m.p.h. (60ft per min)

Third gear ... 2·75 m.p.h. (240ft per min)

Engine speed, automatically governed at all loads ... 2200 r.p.m.

Petrol consumption (average), per working hour ... 3 pints

| | |
|---|---|
| Petrol tank capacity ... ... ... ... | 1 gallon |
| Total Weight (approx.) ... ... ... | 3½ cwt |
| Length with handle bars extended ... | 6ft 7in |
| Length with handle bars at 90 deg.... | 5ft |
| Width (overall) ... ... ... ... ... | 2ft 9in |
| Travel of hydraulic ram (max.) ... | 6½in |
| Large model : | |
| Speeds of operation ... ... ... ... | 2 to 4 m.p.h. |
| Petrol consumption (average), per working hour ... ... ... ... ... | 4 pints |
| Weight (net)... ... ... ... ... ... | 3½ cwt |
| Length (overall) ... ... ... ... ... | 9ft |
| Width (overall) ... ... ... ... ... | 3ft |
| Height (overall) ... ... ... ... ... | 3ft |

(b) *Shunting Machine*

| | |
|---|---|
| Petrol model : | |
| Speeds of operation : | |
| Loaded ... ... ... ... ... ... | 1·86 m.p.h. |
| Empty ... ... ... ... ... ... | 3·73 m.p.h. |
| Petrol consumption (approx.), per working hour ... ... ... ... ... | ¼ gallon |
| Weight ... ... ... ... ... ... | 1·82 tons |
| Length overall (approx.) ... ... ... | 13ft |
| Width overall (approx.) ... ... ... | 3ft 8in |
| Height overall (approx.) ... ... ... | 4ft 1in |
| Electric model : | |
| Speed of operation : | |
| Loaded ... ... ... ... ... ... | 1·86 m.p.h. |
| Empty ... ... ... ... ... ... | 3·73 m.p.h. |
| Weight ... ... ... ... ... ... | 2·3 tons |
| Length overall (approx.) ... ... ... | 12ft 4in |
| Width overall (approx.) ... ... ... | 3ft 7in |
| Height overall (approx.) ... ... ... | 3ft 2in |

(c) *Electric Capstan*

An electric motor of totally enclosed type supplied to suit users' requirements.

The operation is remote controlled by a foot button or hand lever as desired.

| | |
|---|---|
| Speed of operation, per min ... ... ... | Between 45ft and 160ft |
| Fuel consumption per hour ... ... ... | 7½kWh |
| Length of base plate (approx.) ... ... | 5ft 10in |
| Width of base plate (approx.) ... ... | 2ft 11in |
| Height above ground (approx.) ... ... | 1ft 9in |

(d) and (e) *Petrol and Diesel Shunting Tractor*

The details of each model marketed by the two manufacturers are as shown in the table.

| | *Manufacturer A* | *Manufacturer B* |
|---|---|---|
| Operating speeds, m.p.h. ... ... | 1st, 1·8 ; 2nd, 2·6 ; 3rd, 3·3 ; 4th, 4·7 ; 5th, 6·6 ; 6th, 11·8 ; R1st, 2·5 ; R2nd, 4·5 | 1st, 2·3 ; 2nd, 3·2 ; 3rd, 10·0 ; R, 3·1 |
| Wheels and tyres ... | Disc pattern driving wheels fitted with 12·000 × 24—8-ply low pressure tyres ; steering wheels 8·00 × 19 tyres | Disc pattern rear wheels with 12·00 × 24 water ballasted tyres at 35 lb/sq in ; steering wheels 34 × 7 at 30 lb/sq in |
| Plates and couplings | Front plate : top 4ft 4½in, bottom 2ft 4in above rail, and 5ft 9in wide ; rear plate, top 4ft 5in, bottom 2ft 7in above rail, and 5ft 9in wide ; rear coupling is standard pin type automatic coupling fitted if required | Front plate : top 4ft 4½in, bottom 2ft 2in above rail, and 6ft 8in wide ; rear plate : top 4ft 4½in, bottom 2ft 8½in above rail, and 6ft wide ; front and rear couplings are optional ; front coupling is mounted on the front axle and braced to the front buffer plate mounting ; rear coupling is mounted on the transmission housing |
| Drawbar pulls ... | Main drawbar pull 6000 lb ; the tractor is capable of exerting a push in excess of the above figure | Drawbar pulls in bottom gear : over 5000 lb for petrol machine, over 6500 lb for diesel machine |
| Leading dimensions | Overall length (excluding coupling), 10ft 10in ; overall width, 5ft 9in ; track width : front 4ft 4¾in, rear 4ft 8¼in ; height over ballast box, 5ft 1¼in ; height to top of cab, 7ft 6in ; wheel base, 6ft 5in ; turning circle : left hand, 16ft 6in rad., right hand 15ft rad., (ballasted), 3 tons 15 cwt ; ballast compartment over each rear wheel is 6 cubic feet in capacity | Overall length, 11ft 2¼in ; overall width, 6ft 8in ; track width : front 4ft 6¼in, rear 4ft 4in ; height to top of steering wheel, 5ft 4in (approx.) ; height to top of cab, 7ft 2¼in ; wheel base, 6ft 7½in ; gross weight: petrol 3 tons 10 cwt, diesel 3 tons 15 cwt; Ballast weight between wheels, 6 cwt ; water ballasted rear tyres, 6 cwt |

## Appendix II : The Effect of Curves and Gradients on Haulage Capacity

Although gradients affect the haulage capacity of the machines considerably it is not proposed to consider their effect here because, in general, docks and wharves used in the iron ore trade are built on level ground.

Curvature of track, however, is appreciable and from the data given in the accompanying table the relative effect on the haulage capacity of the machines is indicated in Fig. 6.

It will be seen that curvature of track affects the haulage capacity of the heavier machines to a greater extent than that of the lighter machines.

*Data Used in Calculating Effect of Curves on Haulage Capacity*

| Machine | Weight of machine | Rolling resistance, lb/ton | Curve resistance,* lb/ton per degree curve | Remarks |
|---|---|---|---|---|
| Small truck mover ... ... ... | 3·5 cwt | 10 | 0·2 | Will offer no flange resistance as it runs on one wheel. A proportionate curve resistance makes little difference to result. |
| Large truck mover ... ... ... ... | 3·5 cwt | 10 | Nil | |
| Shunting machine ... ... ... ... | 1·82 tons | 20 | Nil | |
| Capstan ... ... ... ... ... ... | — | Nil | Nil | |
| Petrol shunting tractor ... ... ... | 3·5 tons | 40 | Nil | Because this machine is fitted with steering gear the effect of curves has been neglected. |
| Diesel shunting tractor ... ... ... | 3·75 tons | 40 | Nil | |
| Steam locomotive ... ... ... ... | 70 tons | 22 | 1·6 | Standard figures used in British practice |
| Large diesel-mechanical and electrical locomotive | 40 tons | 22 | 1·6 | |
| Small diesel-mechanical locomotive | 30 tons | 13 | 1·6 | |
| Wagons ... ... ... ... ... ... | — | — | 8 | |


References

[1] E. L. Diamond : "Locomotives for Iron and Steel Works," *Journal of the Iron and Steel Institute*, May, 1948.

[2] Ralph P. Johnson : *The Steam Locomotive*, Simmons-Boardman Publishing Corporation, New York.

[3] D. B. Hoseason : "Diesel-Electric Traction," East Midland Sub-Centre of Institution of Electrical Engineers, October, 1945.


# Air Pollution Control in America


By FREDERICK S. MALLETTE, M.A.S.M.E.*



*The earlier part of a James Clayton paper presented to the Institution of Mechanical Engineers last Friday, April 23rd, is here printed. Some reference is made to the history of air pollution legislation in America. Recent work in St. Louis, Allegheny County, New York City, California, Los Angeles County, and Canada is then referred to in more detail. The full paper then studies meteorology, the Donora smog, effects upon health, the development of instruments, problems of the iron and steel industry, control equipment, and socio-economic considerations. Those sections of the paper are not reprinted here.*


### Legislation and Local Accomplishments

In an excellent review of air pollution legislation in the United States, Barkley (1951) reports that one of the earliest lawsuits, if not the first, in which smoke was adjudged a nuisance occurred in St. Louis, Missouri, in 1864. This was followed in the same city, in 1867, by the adoption of an ordinance requiring that the chimneys of all manufacturing establishments be at least 20ft above the adjoining buildings.

This same author records the first ordinance giving a local government specific authority to prevent smoke as being adopted in Chicago, Illinois, in April, 1881. This provided that "the emission of dense smoke from the smokestack of any boat or locomotive or from any chimney anywhere within the city shall be a public nuisance." The fine for violation was from 5 dollars to 50 dollars.

From this period on, and especially around the turn of the century, many American cities adopted ordinances, among the earliest being Washington (District of Columbia), Philadelphia (Pennsylvania), and Baltimore (Maryland). In 1912 the United States Bureau of Mines, in a survey of municipal smoke abatement ordinances (Flagg, 1919), found that twelve cities with a population of less than 50,000 had either a smoke ordinance or an official charged with smoke inspection ; about nineteen cities of 50,000 to 200,000 population were active in the suppression of smoke. Among the twenty-eight cities over 200,000 in population, twenty-three showed activity.

With some notable exceptions, few counties have adopted restrictive legislation on smoke or other air pollution. As a result of the Selby smelter difficulties, Contra Costa County, California, adopted an ordinance, in 1915, restricting "fume" strength. The first example of county-wide legislation and enforcement, which began in 1931, was Hudson County, New Jersey, an area of intensive industrial development. In recent years the outstanding examples of activity are Los Angeles County, California, and Allegheny County, Pennsylvania. In 1947 the former, through a state enabling act, created an air pollution control district, and the latter adopted a broad ordinance in 1949. These developments deserve separate detailed treatment.

Among the States there has been some legislation. Rhode Island passed, in 1909, a statute prohibiting "the emission of dense or thick black or gray smoke—for a longer period than five minutes at any one time within any city of the State having a population of 150,000 or more, only exempting private residences and locomotives during the time of starting and feeding fires therein while in roundhouse or roundhouse yards."

In 1910, Massachusetts adopted a smoke control law for the general area of Boston, based upon readings of the Ringelmann chart. Other States which have adopted legislation are Iowa, Missouri, Louisiana, Ohio, Pennsylvania, and Wisconsin. Most of the State legislation dealing with smoke or air pollution has to do with extending authority to cities or counties.

From time to time there has been agitation for the creation of interstate authorities to handle air pollution, notably in the area where New York City and the State of New Jersey adjoin, but so far nothing tangible has been done. There is precedent for such an arrangement in the field of stream pollution control, and, no doubt, legislation fostering such a relation will be forthcoming in the near future.†

At present there is no national legislation in the United States having to do with air pollution as such, although suggestions have been made to have it taken up by either the Bureau of Mines or the Public Health Service. Both of these groups have taken active part in air pollution studies ; the former, at one of the Government-owned magnesium plants and in the Beaumont-Port Arthur (Texas) and Louisville (Kentucky) areas. In addition, they have published a definitive report of a study made in the Los Angeles area (Allen and others, 1952). The Public Health Service has made, over a period of years, a number of studies of urban air pollution, perhaps the most outstanding of which was made in 1949 covering the Donora (Pennsylvania) area after the "smog" disaster in 1948 (Anon., 1949).

*International Action.*—In international relations there have been two situations involving air pollution between the United States and Canada which have been settled amicably by action of the International Joint Commission which had been set up for this and similar purposes (Fofflund, 1952).

For a number of years damage to vegetation in the State of Washington had been caused by the smelters at Trail, British Columbia. From 1928 to 1931 the Commission was principally engaged in determining the amount of damage caused, and in making awards. In 1935 an Arbitral Tribunal was set up by the two Governments which was charged with (1) determining damage and awarding compensation therefor, and (2) ascertaining whether or not operating practices could be developed which would prevent future damage. This latter activity resulted in extensive studies of meteorological and atmospheric pollution, which added greatly to the knowledge in these fields. They deserve detailed discussion, but limitations of space prevent anything more than reference to publications on this subject (U.S. Bureau of Mines ; Hewson, 1944, page 195).

More recently, the complaints from citizens on both sides of the international boundary in the Detroit (Michigan) and Windsor (Ontario) area about the smoke nuisance caused by vessels plying the Detroit River, have resulted in the


* Research Manager, American Society of Mechanical Engineers, and Executive Secretary of the Committee on Air Pollution Controls.


† The *New York Times*, dated March 12, 1954, reports the passage of a Bill by the New York State Senate to authorise the Interstate Sanitation Commission to undertake a study of air pollution in the New York City Metropolitan Area. This would also require concurrence by the State of New Jersey.

establishment by the International Joint Commission of an air pollution investigation. This undertaking has been expanded, on both sides of the boundary, into a comprehensive study to determine the effect of air pollution on almost every aspect of community life (Peart and Josie, 1953, page 326). To implement this activity a Technical Advisory Board has been appointed with a Canadian section and an American section.

The general objectives of the investigation include a programme to determine the sources, nature and amount of various pollutants in the atmosphere and the effect of meteorological conditions thereon. A study is being made of the effect of atmospheric contamination on health, vegetation, safety, and the economy of the area. Finally, an effort will be made to ascertain control methods for the pollution, the costs involved, and by whom those costs are to be borne.

The initial phase of the study was begun in 1951, and the subsequent reports of the two sections and various other publications have presented the findings. The 1952 report (Clayton, unpublished) will include the following findings :—

The pollution levels have not changed during the two-year period of the study and are high enough to warrant a thorough investigation. Improvements were either insignificant or new sources of pollution from expansion of the community overcame the benefits accomplished.

A marked diurnal fluctuation was noted, the highest values occurring at 6 a.m.

There appears to be no need for micro-meteorological studies, since pollutants rise and fall similarly throughout the area.

Highest concentrations of particles (particulate concentrations) were found in industrial areas and were directly related to the stability of the atmosphere.

The theory that rainfall alone can effectively reduce particulate pollution could be neither affirmed not denied.

During a severe smog, none of the inorganic elements sampled increased sufficiently to be considered an important factor.

When pollution was high the increase in particulate matter appeared to be due to organic constituents.

Sulphur dioxide ranged from 0·02 to 0·05 parts per million in summer to a maximum of 0·11 parts per million in December, based upon 18,000 samples. Peak concentrations have reached a maximum of 2·4 parts per million.

Data collected were believed insufficient to determine the extent of transboundary pollution.

*River Traffic.*—The vessel fleets of the Great Lakes may execute over 28,000 passages of the Detroit River in transporting over 100 million tons of cargo in a season. The Canadian section, which has been responsible for the collection and reporting of data on smoke emissions from vessels, reports (Katz, 1952*b*) a marked improvement in smoke performance as a result of efforts made by the Dominion Marine Association and by the Lake Carriers' Association under their Great Lakes Air Pollution Programme, organised in 1950. In that year the percentage of smoke observations corresponding to No. 3 Ringelmann or darker amounted to about 51 per cent. In 1951 this figure was reduced to about 35 per cent. Improved specifications for fuel, approved steam-air jet installations for stoker-fired water-tube boilers, an educational programme for personnel, and research on combustion aids for hand-fired Scotch marine boilers will probably still further reduce excessive smoke from the vessels.

In discussing relatively high, mean and peak values for sulphur dioxide, Katz points out that those found in the Detroit River area are more serious than in many other polluted areas and that " the possibility of a major disaster in the Detroit River area is rendered unlikely on the ground only of its topography, but, with increasing industrialisation, toxic levels of pollution are being built up to serious proportions " (Katz, 1952*b*).

*Model Ordinances.*—In 1912, the United States Bureau of Mines suggested " model " or " example " ordinances for small, medium-size, and large towns, based upon those rules in effect in Chicago and Des Moines. In 1924, a committee, composed of representatives from the American Society of Heating and Ventilating Engineers, the Stoker Manufacturers Association, the American Civic Association, and the American Society of Mechanical Engineers, prepared a comprehensive ordinance which contained engineering regulations on equipment dimensions. This model served as a guide for many towns.

The A.S.M.E., in 1949, published a bulletin prepared by a committee of the Fuels Division. Entitled " Example Sections for a Smoke Regulation Ordinance " (Model Smoke Law Committee, 1949), it contains fifteen example sections with added helpful comments. In part or in whole, the sections have been used for making changes in old ordinances and as a basis for new local ordinances by over 100 towns. The ordinance recommended by the Coal Producers Committee for Smoke Abatement is based upon the A.S.M.E. model.

To consider the legislation and accomplishments of every area in the United States and Canada that is active in air pollution control would require a separate treatise. Therefore only those places where outstanding efforts are being made are discussed. However, this does not imply that others are not making progress.

### St. Louis, Missouri

Probably the first large city that made an effective reduction in smoke pollution was St. Louis. Prior to 1940 the city was subject, particularly in the winter season, to smogs so dense that it was not infrequent to have street lights and automobile headlights burning until noon (Carter, unpublished).

St. Louis had established a Division of Smoke Regulation in the Department of Public Safety, in 1937, by an ordinance similar to those in common use in other American cities. It prohibited the emission of dense smoke, provided for fines upon conviction in the Police Court, and permitted the commissioner to seal offending furnaces. It required the obtaining of permits for all new fuel-burning equipment and inspection thereof in the field after installation. It also required that all bituminous coal containing over 12 per cent ash or 2 per cent sulphur be washed to an ash content of not over 12 per cent. This ordinance did not succeed in improving conditions.

In December, 1939, the Mayor of St. Louis appointed a committee to investigate the smoke problem and to make recommendations. The committee concluded that local smoke pollution resulted from an almost universal use of high-volatile bituminous coal for heating as well as for power. They recommended that the use of such coal be restricted to mechanical fuel-burning equipment, and that all fuel for hand firing be of the " smokeless " type.

These recommendations were enacted into an ordinance in 1940. The ordinance prohibited the sale of high-volatile coal in the city, except in sizes under 2in, and the washing provisions were continued. All these provisions, plus strict enforcement in spite of the war, brought about a tremendous change in the atmospheric conditions in St. Louis. For the year ended April 1, 1953, the local United States Weather Bureau (located in downtown St. Louis) reported only 5½ hours of moderate smoke on three days during the preceding twelve months. For the seven months from September, 1939, until March, 1940, the same office reported 716½ hours of smoke. The situation is even better than these figures indicate, because the Weather Bureau changed its visibility standards during the interim.

The economic returns which may result from such an improvement may be estimated from a consideration of an earlier report (Anon., 1927) by the St. Louis Citizens' Smoke Abatement League, of an estimated cost of the smoke nuisance of over 14,000,000 dollars for additional laundry, dry cleaning, and decorating bills, deterioration of sheet metal and exterior surfaces, loss of merchandise on shop shelves, the extra cost of artificial illumination, and so forth.

In its publications (Carter, 1946), the Missouri Botanical Garden has pointed out the defoliating and other damaging effects on plants during smoke palls of a duration of less than twenty-four hours. In January, 1941, when the ordinance had been in effect only a short time, the Garden's bulletin mentioned beneficial results. " Certainly," it stated, " there has been such a marked improvement that one is inclined to become optimistic about the possibilities for successful gardening in the city."

Five years later the Garden's director affirmed that the optimism was justified. The city's floriculturist had observed the same results in the parks and greenhouses. The St. Louis forester stated : " Now we feel safe in planting evergreens and even juniper in our downtown area. Previous to the adoption of the city smoke ordinance this was unthinkable."

Of thirty-three nose and throat specialists, twenty-nine were in almost unanimous agreement that " there has been a very definite reduction in infections of the upper respiratory passages and of the tracheo-bronchial tree." The eye specialists have noted a similar, if less marked, reduction in certain affections of the eye (Carter, 1946).

While it is difficult, because of inflation, to determine savings from cleaner air in terms of dollars, it can be done in terms of labour. This was found to be true for maintenance of downtown office space. Surfaces are easier to paint than before because of the absence of soot and grime, and the wearing quality of painted surfaces, particularly on the exterior of buildings, has been increased by at least 25 per cent (Carter, 1946). In addition, the city has been beautified by the restoration and cleaning of many structures, which formerly had not been done because those structures would have become soiled again so quickly.

Householders and apartment house owners report much less cleaning and maintenance is required than previously. Department stores and retail establishments claim lower losses from soiled merchandise. The filters in air conditioning systems do not require cleaning so often. The Union Electric Company, of St. Louis, claims that a saving of 75,000 dollars a year in lighting bills has been made because of reduction in atmospheric smoke. All of these results were achieved by the elimination of three-quarters of the smoke from the atmosphere.

### Allegheny County, Pennsylvania

No definitive discussion of activity in the field of air pollution control would be complete without a consideration of the accomplishment made in Pittsburgh and Allegheny County. Only those who have a vivid recollection of the former " black " days can fully appreciate the difference in present-day Pittsburgh. Although the city and county each have an air pollution ordinance, and there is some question as to whether the one supersedes the other, the dramatic improvement in Pittsburgh atmosphere appeared after the enactment of the county ordinance in 1949. Most probably the great civic movement known as the Allegheny Conference on Community Development provided the stimulus and backing necessary to bring about the present change in the atmosphere of the area.

Although it is entitled a " Smoke Control Ordinance " and is based in part upon the A.S.M.E. " Example Sections for a Smoke Regulation Ordinance," the county legislation has as its intent the eventual control of other air pollutants. It accomplished this by including all " fuel-burning " equipment and by restricting not only smoke, but also fly-ash in the waste gases.

The general provisions apply to all classes of fuel-burning equipment with certain exceptions. Smoke of a shade or appearance darker than No. 2 of the Ringelmann chart is prohibited except in the event of breakdown or other failure not reasonably preventable. Excessive violations of this provision may result in sealing of the equipment when proved by the procedures of the A.S.M.E. " Power Test Code—Test Code for Dust Separating Apparatus, PTC-21-1941," or modifications thereof.

One of the important items of both city and county ordinances which had an early and marked effect upon the county's atmospheric condition is the definition of solid fuel for hand-fired equipment. The county ordinance states that the volatile content of several enumerated solid fuels must be 23 per cent or less (for the city, 20 per cent or less) on a dry basis, as determined by the test procedure of the American

Society for Testing Materials. Those requirements almost at once freed the Pittsburgh air of its depressing smogs. However, at its effective date the county ordinance applied only to non-domestic hand-fired or surface-burning types of fuel-burning equipment ; namely, central station power and heating plants, industrial power plants, and heating plants as defined.

Domestic hand-fired heating plants were not required to conform to the special solid fuel requirements of the county ordinance until June 1, 1953. When the heating season began in the autumn of that year, there was some organised resistance on the part of domestic users, especially in some of the suburban areas where there was easy access to lower-grade fuels. The county supervisors refused any further extension of the four-year period of grace, and there is no present evidence of extensive resistance to compliance.

To continue specifically with the county ordinance, a special section deals with locomotives and portable boilers. Although this section is restrictive and requires proof of progress in control of pollution, it has been rendered partially obsolete and the overall pollution problem has been markedly reduced by the almost complete replacement of steam locomotives, cranes, and other steam-powered equipment by diesel-powered units. The report of the Allegheny County Bureau of Smoke Control for the year ended May 31, 1953, which was released in January, 1954, states that four Class 1 railways were completely converted to diesel-powered equipment during the year and that the railways supplying commuter service have placed in operation a number of self-propelled cars, presumably diesel powered. The research programme which had as its purpose the elimination of 75 per cent of the cinders emitted by steam locomotives was unsuccessful, but the rapid substitution of diesel motive power for that of steam rendered this failure unimportant.

The provisions of the county ordinance covering the iron and steel industry included a number of exceptions and special sections, as follows : smoke control regulations do not apply to blast-furnaces, by-product coke plants, open-hearth furnaces, sintering plants, Bessemer converters, or to cupolas except that a limit for fly-ash control (0·50 lb per 1000 lb of gases, but not more than 85 per cent of the total fly-ash) is provided for blast-furnaces new or completely rebuilt subsequent to the enactment of the ordinance (and, after ten years, for all blast-furnaces). Bleeding of cleaned gas only is required. By-product coke plants, open-hearth furnaces, and sintering plants are required to incorporate "economically practical" controls of smoke and fly-ash. Blast-furnace "slips" are exempted from fly-ash limits, but research on this problem and also on control of open-hearth and Bessemer converter effluents must be undertaken or participated in by persons responsible for their operation. Emission limits are provided for heating furnaces, puddling furnaces, cupolas, and air furnaces.

The provisions of the city ordinance dealing with Bessemer converters are most stringent. These converters may not emit "such quantities of soot, cinders, noxious acids, fumes or gases in such place or manner as to cause injury, detriment or nuisance to any person or the public," and, in addition, their fly-ash emission is subject to an A.S.M.E. test for quantity and particle size. It is of interest that there are now no Bessemer converters in the city of Pittsburgh and only three in the county.

All this emphasis on the air pollution problems of iron and steel production in Allegheny County and elsewhere has served to generate intensive study of the effluents of this industry and their control. This subject is more fully treated later.

Other provisions of the county ordinance govern commercial incinerators, towboats, and other river craft, open fires, cement plants, and all other equipment emitting smoke. Of particular interest in this connection are the accomplishments which have been made in controlling the fires of gob piles (spoil banks, i.e. slag heaps) at coal mines or coal preparation plants. It is reported that one of these piles in Allegheny County had burnt, until it was extinguished recently, for approximately forty-five years.

The county ordinance provided an interim of five years for mine operators to find effective solutions in preventing future fires. During that period progress was made towards developing better methods of piling the refuse. The Western Pennsylvania Coal Operators Association has sponsored work on the overall problem at Mellon Institute, Pittsburgh, and at the Pennsylvania State College. The United States Bureau of Mines has undertaken an investigation of certain aspects of the problem, and experimental work is being done there which will complement rather than duplicate other activities.

No specific studies of the air pollution problem caused by burning gob piles are available, but the many instances of odour complaint, house paint blackening, and damage to vegetation, as well as the occasional fatality of coal pickers or of "derelicts" seeking warmth, brand them a nuisance and a harzard to the community. Concentrations of carbon monoxide have been found to be as high as 1500 parts per million on the surface of a burning pile, 340 parts per million at 8in above the surface, and only at 6ft above the surface did the concentration fall to zero. No figures are available for hydrogen sulphide or sulphur dioxide in the vicinity of these piles, but an observer passing to windward of a burning pile cannot fail to note the presence of these gases.

The dearth of field studies of the air pollution resulting from burning piles should be remedied. Better information would assist in the establishment of standards which could be used in considering legislation.

The Coal Waste Fellowship at Mellon Institute has been engaged in the following activities (Allegheny County (Pennsylvania) Bureau of Smoke Control) :—

(1) Development and application of a calorimeter for the precise measurement of the spontaneous heating of small samples of powdered coal and associated pyrites in the normally prevailing atmospheric temperature range.

(2) Field study of methods of refuse disposal and pile construction (compacting, sealing and crushing operations, all in conjunction with layer disposal of refuse) and methods of refuse fire control (spraying, grouting and compacting operations). Improvements in these operations have been suggested.

(3) Educational efforts to arouse the interest of the operators in applying known control methods.

The State of Pennsylvania provided funds, which it required the industry to match, which supported work at Pennsylvania State College on engineering studies on refuse pile fires, the construction of refuse piles, the cost of combustion control, and observations on the most promising control methods.

The United States Bureau of Mines (Graf, 1952) has exerted its efforts on studies of methods for the prevention of gob fires and the possible utilisation of gob material. They found that methods of mining played an important part in the amount and composition of the refuse. For example, if less bony material and pyritic binder were to be mined and if more of the gob were to be stored underground in abandoned workings the problem would be simpler.

Coal preparation affects the composition of the gob and the subsequent behaviour of the pile. Crushing the refuse is an important factor in preventing fires. While the finer particles are chemically and physically more active, the reduction of ventilation within the pile and the more rapid disintegration of rock material make up for the effect of increased surface. If washery refuse is separated into two ranges of sizes with differing pyritic content (and thus different affinities for oxygen) and if mine rocks are crushed for sealing material, spontaneous heating may be prevented.

Further experimental studies of mine refuse fires have been summarised (Corey, unpublished) as follows :—

"For the past two years the Bureau of Mines has been conducting a series of investigations with the objectives of evaluating the variables that cause spontaneous heating in mine refuse piles and of devising practical procedures for preventing spontaneous ignition in such piles. The laboratory studies have been carried out in specially designed test boxes, in which the important variables can be controlled, and the field studies have been made on refuse piles at a large local underground mine with a modern coal preparation plant. This plant handles about 1000 tons per day of washery refuse.

"Two identical test boxes were designed and constructed for handling 2000 lb of refuse each, and were provided with electrical strip heaters in a manner to produce a localised hot spot within the charge. The power input to these heaters was increased stepwise to simulate the gradual development of the hot spot. The use of two boxes made it possible to conduct check tests or two tests under different conditions, simultaneously.

"Five tests have been completed, three with ¼in and 0in refuse of different moisture contents, one with 3½in and ¼in refuse, and one with 3½in and 0in refuse.‡ The original refuse was 3½in and 0in, and all came from the same source. Its pyrites content was about 5 per cent, the fines containing about 15 per cent and the coarser material about 3 per cent of pyrites.

"The ¼in and 0in was heated stepwise in the test box until the heating elements were 900 deg. Fah. and no evidence of spontaneous heating was found. However, for the same rate of power input to the heaters the 3½in and ¼in fraction began to burn spontaneously at 400 deg. Fah. and the 3½in and 0in at 200 deg. Fah.

"It was concluded from these tests that size consist (content) may be the most important variable in spontaneous ignition of coal, as it controls the amount of ventilation of a pile, other things being constant. Laboratory tests had shown previously that the relative air permeability of 3½in and 0in, the 3½in and ¼in, and the ¼in. and 0in, sizes were 5, 25 and 1, respectively. The pyrites content and the specific surface of the gob appear to be of secondary importance. Further tests are scheduled to evaluate the magnitude of the specific effects of these variables.

"Since the fines were found to be comparatively inert, arrangements were made with the co-operating mining company to separate the fines from the refuse and use them, instead of loam, to seal the flanks of mine refuse piles at the mine site. This procedure has been used successfully for about one year. Its only shortcoming is the tendency for heavy rains to erode the layer of fines on the flanks of the piles, which necessitates some maintenance at such times. The net savings over previous practice, however, are substantial. Moreover, fires in two piles were successfully extinguished by sealing them with fines."

As for utilisation of gob material, the Bureau dismissed several proposed uses because of limited application or economic impracticability. Among them are the following : recovery of tars and chemicals, production of activated carbon and of carbonaceous exchangers for water softening, recovery of rare elements, such as germanium or gallium, the use of crushed gob as a soil darkener and as ground fill. "Red dog" (burnt rock for road aggregate) is the only present commercial product of gob utilisation, but it causes air pollution.

Some of the more promising prospects of gob utilisation are the heating value of gob to be used for power generation, the recovery of pyrites and marcasite, and its chemical processing for the recovery of sulphur.

However, so far as air pollution control is concerned, the best remedy appears to be to avoid the conditions which support combustion. A summary (Zimmerman, 1952) of the replies to a questionnaire disclosed that, of 487 piles, 158 were burning, 231 were not burning, and ninety-eight were burnt out. While over 60 per cent of the replies indicated that no method of control was being used, there were others which listed various procedures in use. Such procedures were layer piling with or without clay, sealing with clay or fly-ash, digging out and back-filling, crushing, or use of water.

Proper piling seems to hold the most promise in gob fire prevention. It was found difficult to generalise as to what constitutes proper piling, but certain fundamental principles have been laid down (Anon., 1952). Using cut and fill in hilly terrain every effort should be made to have the edges of the pile sealed against an impervious barrier. The optimum thickness of layers

‡ 0in, as used in refuse dimensions, indicates that fines were included.

probably depends on local factors, but, when laid down, the layers should be kept horizontal and approximately 4ft to 6ft deep. A rule which seems to give good results is to use a layer which, when compressed, yields a final thickness of 2ft.

For modern coal preparation plants with a large tonnage of refuse (2500 tons per day or more), proper disposal presents a formidable problem which requires careful consideration and planning. At present, however, well-compacted and sealed refuse piles offer maximum protection against fire. Compaction of the edges of the pile can be easily attained by the use of an edge roller.

*(To be concluded)*

## Institute of Metals Spring Meeting

THE spring meetings of the Institute of Metals began in London on Monday last. This year they are being held jointly with the Société Française de Métallurgie, and next week the members of the Société and their ladies will spend two days in the provinces visiting works and research organisations and other places of technical and general interest. The opening meeting was held at the Royal Institution, and at it a welcome to the members of the Société Française de Métallurgie was expressed by Professor F. C. Thompson, the retiring president of the Institute of Metals, and by Sir Cyril Hinshelwood, foreign secretary of the Royal Society. The May Lecture, entitled " The Domain Structure of Ferromagnetic. Metals," was then delivered by Professor L. F. Bates, F.R.S.

The annual general meeting of the Institute of Metals was held on Tuesday morning, when Dr. S. F. Dorey, M.I.Mech.E., F.R.S., was installed as president. The annual report of the council, which was presented at the meeting, showed that at the end of last year the total membership of the Institute was 4299. The report noted that an invitation had been accepted for the Institute to hold its autumn meeting in Switzerland from September 6th to 14th next. The report also stated that, in co-operation with the council of the Iron and Steel Institute and the councils of other European metallurgical societies, an invitation had been issued to certain American metallurgical societies to hold a meeting and to tour some European metallurgical centres in June, 1955.

After the formal business of the annual meeting and the presentation of Institute medals and students' essay prizes, Dr. Dorey delivered his presidential address on the subject of " Metals and Marine Engineering." In the course of the address, Dr. Dorey said that the development and extension of the applications of non-ferrous metals and alloys were dependent on the close co-operation between all who were directly and indirectly concerned with the various phases of research, production, and utilisation of these materials. That axiom was appreciated by the founders and pioneers of the Institute, who also recognised that stimulation of interest in non-ferrous metals was dependent on ensuring that the interests of all members should be regularly and systematically covered by contributions to the *Journal*. In recent years, he thought, there had been a tendency for the theoretical and scientific aspects to be overstressed at the expense of practical considerations.

Dr. Dorey then proceeded to survey the outstanding developments in the application of non-ferrous metals in marine engineering, which had occurred since 1908, the year in which the Institute was founded. In his " conclusions," he said that, within the scope of the survey, some of the merits and limitations of non-ferrous metals in marine engineering had been considered. Combating corrosion still provided the most important function of these metals, and although improved alloys had reduced the rate of deterioration against some forms of this attack, there was still plenty of scope for further developments. For elevated-temperature applications, low and high-alloy steels had replaced non-ferrous metals in steam plant and in steam turbine and gas turbine compressor components. The Nimonic alloys, however, were preferred by many manufacturers for gas turbine blading and similar stressed components.

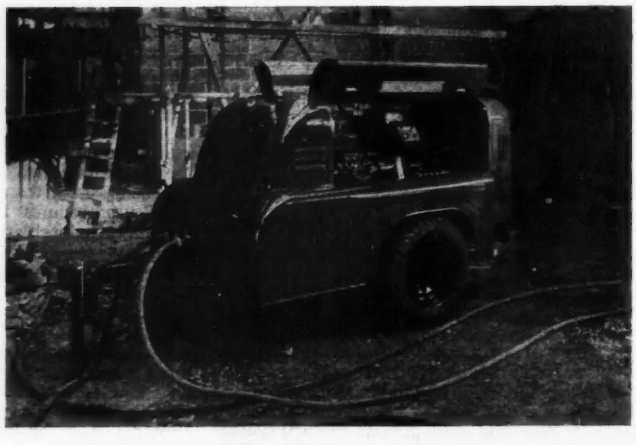
Light alloys, Dr. Dorey remarked, were still at an early stage of development for shipbuilding purposes. Their future progress was largely dependent on a reduction in cost for the equivalent steel structure, and this could be related to the necessities of improvements in both material and fabrication methods. Whilst there was a trend for plain bearings of steam turbines to be of the steel-backed, thin-shell, white-metal types in place of the existing thick-shelled, bronze-backed types, similar trends were impossible in heavy oil engines. Fatigue failures of the thick-shelled, white-metal bearings used in those engines were not infrequent, and bearing metals of improved strength and capable of use with plain carbon steel journals would be advantageous.

But, Dr. Dorey observed, many of the non-ferrous metals used had limitations of resources and production. In consequence it was undesirable that either the engineer or the metallurgist should restrict his views too greatly in considering alloys for particular service. With the large number of existing alloys and the prospect of further increases in the future, close co-operation between engineer and metallurgist was desirable in order that the most efficient and economical selections of material might be made.

Technical sessions for the presentation and discussion of papers followed on Tuesday afternoon, Wednesday, and yesterday (Thursday) morning, and several official visits have been made in the London area by those attending the meeting. A banquet and dance took place at Grosvenor House on Wednesday evening, and to-day (Friday) a further programme of visits in London and the home counties is being carried through.

## Portable Air Compressor

A PORTABLE air compressor now being made by the Atlas Diesel Company, Ltd., of Wembley, Middlesex, is illustrated in the photograph we reproduce below. This compressor is designed for a maximum working pressure of 100 lb per square inch and, with a free air delivery of 110 cubic feet per minute, is arranged for operating two pneumatic tools. It is driven by a Ford industrial diesel engine and, without modification to the chassis, it can also be supplied with either a Ford vaporising oil engine or petrol engine.



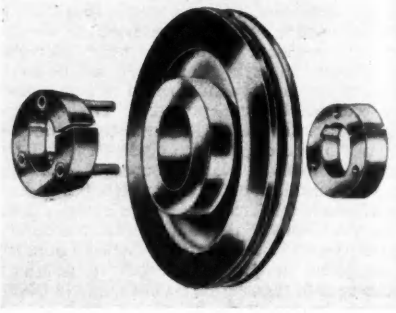
**Portable Air Compressor Fitted with a Ford Industrial Diesel Engine**

The two-stage, two-cylinder, single-acting, air-cooled compressor is fitted with a regulating valve with an adjustable unloading device to operate between 100 lb and 85 lb per square inch. It has an engine speed reducer for light and no-load running and is driven through a 12in diameter automatic centrifugal clutch arranged to engage at 400 to 500 r.p.m. The standard equipment of the compressor also includes an air intake filter, an intercooler with a safety valve, a flywheel and fan for the intercooler.

The complete unit is built on a steel chassis, mounted on two pneumatic wheels on a sprung axle, and it has overrun brakes and a hand-operated parking brake lever. When not in use folding side panels can be lowered to protect the engine and compressor and prevent unauthorised use of the machine.

## Taper Locking Pulley

PULLEYS now being made by the Zerny Engineering Company, Ltd., Oppidans Mews, London, N.W.3, are fitted with a simple, effective means of locking on to shafts through two split taper bushes. One of the firm's vee belt pulleys and its twin taper bushes can be seen in the illustration. These " Dualock " pulleys, as they are known, are made in a number of sizes up to



**Vee Pulley with Its Twin Split Taper Locking Bushes**

42in diameter with ⅞in grooves, and interchangeable bushes are available in sizes to suit shafts from ½in to 4in diameter. Both the pulleys and the bushes are made of cast iron.

The hubs of the pulleys are bored with a slight inwards taper from each end, and corresponding tapers are machined on the outer faces of the split cast iron bushes. When a pulley and its bushes are assembled on a shaft the bushes are drawn together by means of three socket headed screws. Through the mating tapers of the bore and the bushes the inwards movement of the bushes imparts a wedging action to lock the pulley firmly on the shaft. The splits in the bushes give a sufficient degree of flexibility to compensate for a limited amount of shaft size variation from the standard. The bushes are designed to fit flush on both sides of the pulley, and it is stated that the effectiveness of their wedging action is such that no driving keyways are actually necessary, although they are provided.

The makers point out that this type of hub can be adapted for use with gear wheels, flat pulleys or other special applications.

ARID ZONE HYDROLOGY.—The proceedings of the Ankara Symposium on Arid Zone Hydrology, held in April, 1952, and organised jointly by the Turkish Government and the United Nations Educational, Scientific and Cultural Organisation, have been published by Unesco in its series of publications concerning arid zone problems. Among major problems dealt with at this symposium were the physical and chemical properties of underground water limiting its economic use and the introduction of new methods of water prospecting, especially techniques developed in oil fields. The process of organising a United Nations technical assistance mission for hydrological studies is extensively reviewed in a report on the work of a U.N. team in Afghanistan. Besides permitting an international exchange of views among hydrologists on ground water problems in arid areas, the symposium also brought in scientists from related fields. In the case of ecology, for example, the study of surface vegetation as a method of finding characteristics such as permeability of the subsoil is discussed. The proceedings may be obtained from H.M. Stationery Office, Price 30s.

# Industrial and Labour Notes

### Overseas Trade

Detailed figures of British overseas trade in March were issued at the end of last week. They show the value of exports of United Kingdom goods as £246,400,000, compared with a monthly average of £213,500,000 in January and February. Certainly there were twenty-seven working days in March, against an average of twenty-five in the two preceding months, but, the Board of Trade says, the extent of the increase in exports in March was greater than could be accounted for by that factor.

A statement by the Board of Trade says that the export figures for the last three quarters show a pretty consistent pattern of improvement, amounting to 8 or 9 per cent over the corresponding periods a year earlier. This has been achieved in spite of a tendency for prices to fall, it having been estimated that export prices in March were, on the average, about 2 per cent lower than they were a year earlier. Provisionally, it is estimated that the volume of exports in the first quarter of this year was 9 per cent greater than in the first quarter of last year. The present increase in overseas trade, the Board of Trade explains, results from higher industrial activity in Western Europe and a gradually rising demand in the sterling area and elsewhere. It is also stated that, over the past year, the hold on the United States market has been maintained, and that the progressive relaxation of import controls in Commonwealth countries has been having a useful effect on this country's exports to them.

In the first quarter of this year the Board's statement continues, exports of engineering goods have improved. In the past two years, exports of aircraft have been steadily increasing, whilst, on the other hand, last year exports of road vehicles showed some decline. In the first quarter of this year, however, there was a sharp increase in the exports of all road vehicles, except pedal cycles, and of locomotives. Machinery exports (including electrical machinery) have been stepped up, with increases in farm tractors, textile machinery, air conditioning and refrigerating machinery and generating sets.

### Growth of New Export Industries

The Board of Trade has prepared a survey of the new kinds of commodities, meeting new and growing needs, which in the post-war years have proved to be an important factor in Britain's export trade. In many cases, it says, these newly-developed exports are based on inventions or discoveries made during or after the war, whilst in others the basic research had been done before the war although production on a commercial scale was not undertaken until later.

The survey shows that the biggest group of new exports, by value, has come from the engineering industries. Exports of engineering products listed as "new" last year amounted in value to £16,900,000. They included electronic devices, radio-communication and navigational aid equipment, television equipment, industrial radio-frequency equipment, tape recorders, floor polishing machines, combine harvesters, automatic pick-up balers, and fork-lift trucks. The Board of Trade also comments on diesel locomotives as an important new engineering export. It says that fifty-three diesel and diesel-electric locomotives were exported in 1951 and forty-two last year. Special reference is made in this survey, of course, to the growth of Britain's aircraft exports. The official statistics do not distinguish between new designs of aircraft and aero engines and the older, traditional kinds, but total exports of aircraft and engines have increased from £5,400,000 in 1938 to £64,600,000 in 1953.

The Board of Trade concludes its survey by saying that the growth of new export industries—and the rapid development of other, more established, export industries—reflects the considerable amount of change that has occurred in the commodity pattern of this country's export trade since pre-war. This is especially marked in the increased proportion of engineering products, now amounting to about two-fifths of the total exports, compared with one-quarter in 1938. It is a situation which reflects also the adaptability of many of this country's important industries to the rapid changes which have taken place in world demand for manufactured goods, and the advanced position that has been reached by British industry in many spheres of scientific and technical development.

### British Iron and Steel Federation

In its annual report for 1953, which was published at the end of last week, the British Iron and Steel Federation comments on last year's record steel output of 17,600,000 tons. The report points out that much new plant came into operation with the completion of the first post-war development plan, and says also that last year adequate supplies of raw materials were available.

Last year's level of production made possible an increase of supplies to the home market and the removal of distribution control. Steel imports were reduced from 1,800,000 ingot tons in 1952 to 1,100,000 tons last year, while steel exports rose from 2,600,000 ingot tons to 2,800,000 ingot tons. The report goes on to say that the expansion of production was accompanied by a further increase in productivity, the index of output per head in steel melting and rolling rising by 4 per cent during the year. This rise in productivity, the report observes, helped to offset the rise which took place in domestic costs. Another comment in the report is that the pattern of steel production was guided by the changing requirements of consumers and close attention was paid, in the sphere of longer-term market development, to the problems of competition from other materials and the evolution of new uses for steel.

The iron and steel industry's cost structure, the report says, remained comparatively stable throughout the year, in contrast to the almost continuous inflation of 1951 and 1952. There were some small increases in the cost of raw materials obtained from home sources, scrap prices, for example, rising by an average of 1s. 5d. a ton in February, 1953, to take account of the increase in freight charges in December, 1952. Coal prices were raised on March 2, 1953, with an average effect of 5s. 6d. a ton on the iron and steel industry's purchases, and blast furnace coke prices rose by amounts varying between 7s. and 8s. 3d. a ton on the same date. The costs of home ore and other materials also rose slightly. But the level of iron and steel home trade prices remained almost unchanged throughout the year. The Board of Trade wholesale price index for iron and steel products showed an increase of under 2 per cent, a change which was accounted for almost entirely by the general increase of about 12s. 6d. a ton on March 14, 1953, brought about by the raising of coal and coke prices earlier that month.

The report shows that in the week ended December 5, 1953, there were 174,665 process workers employed in the iron and steel industry. The average weekly hours worked were 46·2, the average weekly earnings being £10 1s.

### Railway Costs

The general secretary of the National Union of Railwaymen, Mr. J. S. Campbell, has put forward, in *The Railway Review*, some views on the financial situation of the railways, particularly in relation to a revision of the wages structure. He says that in the negotiations now going on between the British Transport Commission and the unions "both sides appreciate the difficulties to be overcome in arriving at a satisfactory solution of the wages problem."

Mr. Campbell asserts that the time has arrived when something must be done to enable the railways to meet advancing costs, to scrap obsolete equipment, and to improve and modernise the system. The time has long passed, he says, when railwaymen should be expected "to carry the burden of subsidising industry generally." Mr. Campbell then sets out three alternative remedies, putting first further increases in railway fares and charges. This, he comments, would undoubtedly give rise to vociferous complaints that the nationalised industry is milking the users of transport; and he adds that "it might also have the effect of pricing the railways out of the transport market."

Mr. Campbell's other remedies are subsidy and what he describes as "restoration or restitution." About the latter, he says that the British Transport Commission requires a breathing space in order "to recover from the shock of denationalisation of the greater part of its road haulage undertaking." The railways also require a breathing space in order that new methods and new equipment can be brought into use. Mr. Campbell's suggestion is, therefore, that "the Government should, in recognition of the fact that it took £124,000,000 out of the railway industry during the period of control, underwrite the difference between railway net earnings and 'central charges' for a period of five years." In other words, that the Government should make good any deficit in central charges. By this means, Mr. Campbell claims, although the amount required would be nothing like £124,000,000, there would be a period of calm inside the railway industry, "in which period there ought to be an intensive effort by all concerned to improve further the already high standard of efficiency of the railways, and thus ensure that railways and railwaymen get a square deal."

### Women's Wages in the Engineering Industry

A wage increase for women employed in the engineering industry has been announced following an agreement made between the Engineering and Allied Employers' National Federation and the appropriate unions. Up till now the basic weekly rate for women, aged eighteen and over, has been £4 11s. 6d., and the increase now agreed amounts to 5s. 8d. a week. Weekly increases from 2s. 5d. to 3s. 8d. for girls between fifteen and eighteen are also included in the new agreement.

### Coal Production

The latest report on coal output, issued by the Ministry of Fuel and Power, shows, of course, the effect of the Easter holiday. In the week ended April 17th total production amounted to 4,081,500 tons, and last week to 3,309,200 tons. In the first sixteen weeks of this year, up to last Saturday, coal output amounted to 72,043,900 tons, compared with 72,199,500 tons in the corresponding period of last year. Despite the loss of tonnage during the Easter holiday break, deep-mined production so far this year is still slightly ahead of that in the comparable period of 1953. In the week ended April 17th there were 291,200 workers at the coal face, compared with 293,100 a year earlier.

### European Coal and Steel Community

The second general report on the activities of the European Coal and Steel Community has been published this week. It deals with the year ended April 11th, and records that, since the creation of the Community, there has been steady development of the coal and steel trade which has enabled consumers to benefit from considerable price reductions. In addition, the report says, the most efficient producers have been able to maintain a relatively high level of production and employment at a time when the general economic situation was rather unfavourable.

The operation and development of the common market for coal and steel are described in some detail in the report, and there is also a great deal of statistical information on production and prices, while one chapter is devoted to a survey of labour problems. Here it is stated that the High Authority has been devoting serious attention to the complex problems raised by living and working conditions. The Authority has also continued to take action concerning training and safety, and has initiated investigations into wages and terms of employment.

# Notes and Memoranda

## Rail and Road

FREIGHT YARD REORGANISATION AT PETERBOROUGH.—A reorganisation completed at the marshalling yards at Peterborough on the Eastern Region of British Railways has enabled Peterborough, Wisbech, Spital Bridge, and Crescent sidings to be closed to give an annual saving of £100,000. As a result of this work efficiency has been improved and the unproductive shunting of more than 1200 wagons a day eliminated. Under the new working it has also been found possible to close the Midland and Great Northern line between Peterborough and South Lynn during the night.

BRITISH ROAD SERVICES RADIO EXPERIMENT.—British Road Services have recently carried out an experiment in Leicester with the object of improving the collection of urgent traffic from traders' premises. Three parcel vans, operating in the city, have been fitted with radio sets to enable the carmen to keep in constant touch with the depot traffic office. The vans are equipped with 3W, two-way portable sets. A remote control unit in the traffic office is connected by landline to a 15W fixed set mounted on the water tower of one of the highest buildings in Leicester.

BRITISH MOTOR INDUSTRY'S TRADING REPORT.—The Society of Motor Manufacturers and Traders announces that the rate of British car output in March dwarfed all previous monthly figures with an average of nearly 14,700 a week. Commercial vehicle production averaged nearly 5000 a week. Over the first quarter of the year car output at 183,000 units was greater by 54,000 and commercial vehicle production at 64,700 units greater by 3700 than the numbers made in the first three months of last year. For the first quarter of the year the volume of motor vehicle exports was also greater in each case than in the same period in 1953 ; an increase of 17,000 cars, 84,300 in all, were exported, while an extra 6350 commercial vehicles brought their total to nearly 33,000.

ROAD VEHICLES LIGHTING REGULATIONS.—Existing rules about the size and position of rear lamps and reflectors on road vehicles are being revised as a result of the passing of the Road Transport Lighting Act, 1953. This Act requires pedal cycles and solo motor cycles to have a reflector as well as a rear lamp, and nearly all other vehicles to have two lamps and two reflectors instead of a single lamp, as at present. The proposed new rules for reflectors apply to all vehicles from October 1, 1954. Those for rear lamps will be brought into operation in three stages, as follows : new vehicles by October 1, 1954, existing bicycles and tricycles by October 1, 1955, and all other existing vehicles by October 1, 1956. Reflectors, if circular, will have to have a reflecting surface not less than 1¼in in diameter, or have an equivalent area. The minimum legal size for reflectors now is 1¼in. A minimum size will be fixed for rear lamps for the first time. Those on new or existing vehicles, except motor cycles or sidecars, pedal cycles, and a few special classes, must be not less than 2in in diameter if circular or have an equivalent area. In the case of a motor cycle or sidecar the diameter must be not less than 1¼in. The lamps must have bulbs not less than 6W. The location and other requirements can be obtained from the Ministry of Transport and Civil Aviation.

## Miscellanea

INSTITUTE OF PETROLEUM.—At the annual general meeting of the Institute of Petroleum, which was held in London on April 21st, Colonel S. J. M. Auld, D.Sc., was elected president for the year 1954–55.

MR. W. P. SNEDDEN.—We have learned with regret of the death of Mr. W. P. Snedden, which occurred on Friday last, April 23rd. Mr. Snedden was the chief technical engineer in the rolling mill division of British Timken, Ltd., Duston, Northampton.

ALUMINIUM WIRE AND CABLE FACTORY.—In the article entitled "Aluminium Wire and Cable Factory," which appeared in our issue of April 16th, the speed of the rod from the finishing mill was given as 650ft per minute. We are informed that the correct figure is 3000ft per minute.

ECONOMIC CONDITIONS IN EL SALVADOR.—A survey of economic and commercial conditions in El Salvador, as at November, 1953, has been published by Her Majesty's Stationery Office, price 1s. 6d. It is the latest volume in the series of overseas economic surveys issued by the Commercial Relations and Exports Department of the Board of Trade.

NORTHERN IRELAND TRADE.—The North Ireland Government says that, according to a preliminary review, Northern Ireland's total trade during 1953 was valued at £486,000,000, an increase of £29,000,000 on 1952. Imports totalled £249,000,000, an increase of £8,000,000 compared with 1952, and exports were £237,000,000, an increase of £21,000,000.

MIX DESIGN AND QUALITY CONTROL OF CONCRETE.—The Symposium on Mix Design and Quality Control of Concrete, organised by the Cement and Concrete Association, 52, Grosvenor Gardens, London, S.W.1, which is to take place on May 11th to 13th, as recently announced in this journal, is now to be held at the Empire Rooms, Tottenham Court Road, London, W.1 (on the corner of University Street, near Warren Street Station). This change of venue, the Cement and Concrete Association states, in no way alters the published programme.

BRITISH ASSOCIATION.—The British Association for the Advancement of Science is to hold its annual meeting at Oxford from September 1st to 8th under the presidency of Dr. E. D. Adrian, F.R.S. Dr. Adrian's presidential address, which he will deliver in the Sheldonian Theatre, Oxford, on Wednesday evening, September 1st, will be entitled "Science and Human Nature." This year's president of Section G, Engineering, is Dr. Willis Jackson, F.R.S. His address, which is to be given on Friday, September 3rd, will deal with "New Materials in Engineering."

"ASTRONOMY."—The Science Museum recently commissioned Mr. A. R. Thomson, R.A., to paint a picture representing "Astronomy" for the main entrance hall of the Museum in Exhibition Road, South Kensington, London, S.W.7. The picture is now finished and was displayed to the public in the Museum for the first time on Tuesday last, April 27th. The picture indicates the story of the development of the telescope, showing Galileo using his telescope, at the centre, overshadowed by the great 200in instrument of Mount Palomar, against a background of celestial exhalations and constellations.

COMBUSTION ENGINEERING ASSOCIATION.—The annual conference of the Combustion Engineering Association is to be held at the Grand Hotel, Harrogate, on Thursday and Friday of next week, May 6th and 7th. The programme includes an address by Mr. R. J. Moffat, deputy director of marketing, National Coal Board, entitled "Where is the Coal Board Going ?" and a discussion on "The National Industrial Fuel Efficiency Service." The subjects for discussion on Friday, May 7th, are "Firing Equipments and Their Fuels" and "Operational Defects in Boilers."

INSTITUTION OF ELECTRICAL ENGINEERS.—The Institution of Electrical Engineers states that Mr. N. C. Stamford, M.Sc., M.I.E.E., has been appointed to the secretary's staff as education officer. Mr. Stamford was educated at Highgate School and at the City and Guilds Engineering College, and after a period with Marconi's Wireless Telegraph Company he was appointed Lecturer in Electrical Engineering in the University of Manchester, occupying this position from 1933 to 1944. In the latter year he was appointed Principal of the Marconi College, with additional responsibility for education and training in Marconi's Wireless Telegraph Company, Ltd. He subsequently became deputy education and training officer to the British Electricity Authority.

PROPERTIES OF TIN.—The Tin Research Institute has published a completely revised edition of its book entitled *The Properties of Tin* which was first published in 1934. The new edition presents all the published atomic and nuclear, physical, physico-chemical and metallurgical data concerning pure tin, but does not give data for tin alloys, which are covered in a separate publication of the Institute. The main divisions of the book are under the following headings : atomic and nuclear properties, line spectra, X-ray data, crystallography, optical properties, electrical and magnetic properties, thermal properties, and mechanical properties. The book is intended for libraries and research laboratories, to which it will be distributed, free of charge ; for private readers there is a charge of 2s. 6d. in part defrayment only of printing costs. Copies are available from the Tin Research Institute, Fraser Road, Perivale, Greenford, Middlesex.

JUNIOR INSTITUTION OF ENGINEERS.—The Junior Institution of Engineers states that it has purchased Pepys House, 14, Rochester Row, Westminster, S.W.1, for its headquarters in place of the office at 39, Victoria Street, where it has been since 1901. The Junior Institution of Engineers, which began in 1884 as an association of apprentices in the famous engineering works of Maudslay, Sons and Field, Ltd., in Lambeth, is in point of years the tenth oldest engineering institution in London and now has a membership comprising representatives of practically every branch of engineering, extending all over the world. Pepys House, which was the Parish Office of the parish of St. Stephen with St. John, Westminster, has a distinctive elevation of red brick, with stone facings, characteristic of the late nineteenth century, when it was built. It takes its name from Lady Emily Pepys, who was an assiduous worker among the poor of the parish from about 1869 to the early nineties, and was formally opened in 1896 by Dr. Frederick Temple, the then Archbishop of Canterbury.

## Contracts

THE AIRCRAFT DIVISION OF VICKERS ARMSTRONGS, Ltd., announces that it has received orders for two more "Viscount" airliners.

BRITISH INSULATED CALLENDER'S CABLES, Ltd., has received an order from the British Electricity Authority for the first 132kV aluminium-sheathed oil-filled cables to be installed in this country. The cables, which are of single-core construction, are part of a contract awarded to B.I.C.C. for the supply and installation of both lead-sheathed and aluminium-sheathed 132kV oil-filled cables in the 275kV substation at Elstree, Hertfordshire. The aluminium-sheathed installation will include three straight joints, which, although of standard electrical design, will involve the application of plumbing techniques developed from experience of jointing lower-voltage aluminium-sheathed cables. The cable consists of an 8mm oil duct, round which is formed the conductor, consisting of fifty-seven 0·102in plain copper wires, giving a sectional area of the conductor of 0·45 square inch. Over the paper insulation is a metallic screen and a copper woven fabric tape. The aluminium sheath is 0·11in thick and, when swaged down, gives the cable a diameter of 2·35in. The protection consists of layers of P.V.C. rubber and hessian tapes. The overall diameter of the cable is 2·81in and the weight is 16·8 lb per yard, compared with the lead-sheathed cable, which has an identical conductor size, but has an overall diameter of 2·59in and weighs 23·7 lb per yard. The bending radius is similar for both cables. The aluminium-sheathed cable is designed to operate at a maximum stress at the conductor of 85kV/cm. The installation will be carried out this year by British Insulated Callender's Construction Company, Ltd., and will involve laying the cables direct in the ground and terminating them in outdoor sealing ends.

THE NORTH OF SCOTLAND HYDRO-ELECTRIC BOARD has placed the first of the main contracts for its Loch Shin hydro-electric scheme (Constructional Scheme No. 32). George Wimpey and Co., Ltd., has been awarded the contracts to build the Shin generating station and tunnel and Lairg dam. The tunnel will be 5 miles in length. Lairg dam will be 38ft high and 1370ft long. R. J. McLeod (Contractors), Ltd., Glasgow, has been given the contract to construct the Cassley generating station on the south shore of Loch Shin. The value of the contracts is approximately £5,000,000. Annual production of electricity from the scheme will be in the region of 154 million units. The civil engineering consultants are Sir Murdoch MacDonald and Partners.

## Personal and Business

MR. W. E. RUMBELOW has been transferred to the Rhodesian branch of Matthew Hall and Co., Ltd.

COLONEL SIR HAROLD SMITH, K.B.E., has joined the board of Redheugh Iron and Steel Company (1936), Ltd., Gateshead.

MR. ALAN GRANT has been appointed manager of the sales department (cable estimating) of Johnson and Phillips, Ltd., Charlton, S.E.7.

MR. RALPH LYSELL has joined Scientists and Technologists Engineering Partnership, Ltd., Abbey House, Victoria Street, London, S.W.1.

A. LUSON AND SONS, Ltd., Park Royal, London, N.W.10, announces that its title will be changed on May 1st to Gem Brushes (Luson), Ltd.

THE ADMIRALTY GUNNERY ESTABLISHMENT has moved to Southwell, Portland, Dorset. The Admiralty Research Laboratory remains at Teddington, Middlesex.

MR. J. P. FORD, managing director of Associated British Oil Engines (Export), Ltd., has been elected chairman of the council of the Institute of Export.

THE MORSE CHAIN COMPANY, Ltd., has opened a West Midlands stock depot at Belmont House, 15, Belmont Row, Birmingham, 4 (telephone, Aston Cross 3751).

MR. E. D. HART, A.M.I.E.E., has been appointed deputy director, and Miss G. E. Moss, secretary, of the Scientific Instrument Manufacturers Association, 20, Queen Anne Street, London, W.1.

MR. F. S. STENNER is relinquishing his position as chief engineer of Glyndova, Ltd., Lagos, to become resident manager and technical representative in West Africa of Stenners, Ltd., and E. V. Twose, Ltd., Tiverton.

HACKBRIDGE AND HEWITTIC ELECTRIC COMPANY, Ltd., Walton-on-Thames, Surrey, announces the appointment of Mr. I. H. Hedley, M.I.E.E., as technical adviser and sales representative in Northern England and the Midlands.

THE UNITED STEEL COMPANIES, Ltd., state that Mr. T. S. Kilpatrick, director and commercial manager of Workington Iron and Steel Company, has been appointed, in addition, a director of Distington Engineering Company, Ltd.

B.S.A. TOOLS, Ltd., Birmingham, announces the following appointments :—Mr. G. A. Jennings, manager of the small tools division, Sparkbrook ; Mr. H. Williams, plant engineer at the headquarters factory at Mackadown Lane ; Mr. J. H. Woods, commercial manager of the small tools division.

A. A. JONES AND SHIPMAN, Ltd., Leicester, states that Mr. E. J. Townsend has relinquished his position as sales director to become managing director of a newly formed English subsidiary of the Ex-Cell-O Corporation, Detroit, for which A. A. Jones and Shipman, Ltd., has been, for some years, the British selling agent. Mr. K. H. Bishop has been appointed general sales manager of A. A. Jones and Shipman, Ltd.

PROJECTILE AND ENGINEERING COMPANY, Ltd., announces the formation of a subsidiary company to deal with all home and overseas sales of its products. The subsidiary is entitled Peco Machinery Sales (Westminster), Ltd., and its offices are at 28, Victoria Street, London, S.W.1 (telephone, Abbey 1793). Mr. A. J. Chambers, managing director of the parent company is chairman of the subsidiary, and Mr. L. W. Lees has been appointed sales manager.

DAVID BROWN TRACTORS (ENGINEERING), Ltd., Meltham, Yorkshire, states that it has made an agreement whereby Booth, Macdonald and Co., Ltd., Christchurch, New Zealand, will assemble David Brown implements. In the first instance, the components will be shipped from the United Kingdom, but the agreement provides for the manufacture by Booth, Macdonald and Co., Ltd., of an increasing number of components from raw materials obtained from New Zealand sources. Todd Bros., Ltd., will continue to market the David Brown products in New Zealand.

# British Patent Specifications

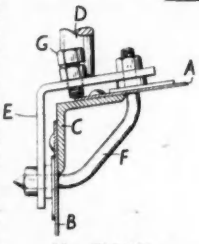
*When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.*

*Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. 8d. each.*

## SAFETY DEVICES

**706,369.** January 10, 1952.—GUARD RAILS FOR GAS-HOLDERS, John Williamson Fletcher, "Pax," Birmingham New Road, Tividale, Tipton, Staffordshire.

In the drawings *A* is a roof sheet and *B* a wall sheet of a gas-holder connected by an angle curb *C*. A standard or pillar *D* for a guard rail is carried by a plate cleat *E* which straddles the corner of the holder. The cleat is held in position by nuts on the ends of a cranked bolt *F*. The cleat is spaced from the roof and wall sheets by thin, square nuts. To facilitate fitting the cleat the end of the bolt *F* which extends through the wall sheet is preferably received in an open-ended slot in the vertical limb of the cleat so that the cleat can be fitted over the upper end of the bolt first and then swung down over the lower end of the bolt. The upper part of the cleat is of substantial width and set-screws *G* adjacent to its side edges on opposite sides of the pillar bear against the roof sheet and prevent the cleat from rocking.—*March* 31, 1954.

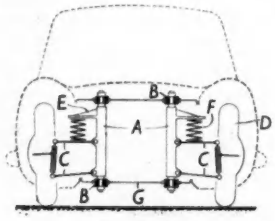



No. 706,369

## ROAD TRANSPORT

**706,604.** May 26, 1952.—AXLE UNITS FOR VEHICLES, Daimler-Benz Aktiengesellschaft, Stuttgart-Unterturkheim, Germany.

Referring to the drawing, *A* indicates two substantially vertical supports, the ends of which are of pivot form and are engaged in rubber rings *B* fixed in supports. These rubber rings not only serve to resist endwise thrust of the supports but by gripping the pivot-form ends they also serve as torsion springs resisting turning of the supports about their vertical axes. Each of the supports is shown formed with protuberances for the attachment of upper and lower links *C* employed for the parallel suspension of a road wheel *D*. In addition, each support *A* is formed near its upper end with a laterally projecting bracket arm *E* which serves as an abutment for the upper end of a compression spring *F* the lower end of which presses down upon the upper one of two superposed links *C*. In the illustration, the rubber rings *B* of the lower mountings are supported in socket-like formations of the lower wall *G* of the vehicle, whilst the rubber rings of the upper mountings are supported in sockets of a cross plate or member.—*March* 31, 1954.

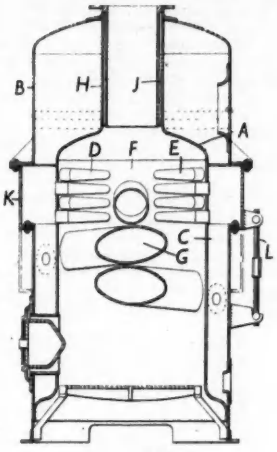



No. 706,604

## STEAM GENERATORS

**705,595.** December 22, 1950.—THIMBLE TUBE BOILERS, The Clarkson Thimble Tube Boiler Company, Ltd., 15, Fetter Lane, London, E.C.4 (*Inventor: Samuel William Spurr.*)

The drawing shows a boiler comprising an inner shell *A* and an outer shell *B* separated by a water space *C*. Two banks *E* and *D* of thimble tubes are supported by the inner shell and these tubes extend into a gas flow space *F*. The inner shell further supports three cross tubes *G*, which are equally spaced around the axis of the boiler and extend across the gas space slightly to the horizontal. The uppermost cross tube is disposed between the banks of thimble tubes. The inner and outer shells are of welded construction, and just above the thimble tubes the inner shell is reduced in diameter to form a chimneylike portion *H*. It is provided with a cast iron liner *J* secured at the upper end to the portion *H* and extending downwards and slightly spaced from the chimney portion. An intermediate cylindrical part *K* of the outer shell, coaxial with and of larger diameter than the upper and lower parts of the shell, is arranged to be lowered from its normal position, as shown in full lines to a position shown by the broken lines, for the purpose of providing access to the interiors of the thimble tubes in the banks and to the cross tube. Three screw jacks *L* equi-spaced around the outer shell are employed to raise or lower the intermediate part. Access to the cross tubes is provided as shown by handhole doors.—*March* 17,1954.




No. 705,595

## CIVIL ENGINEERING

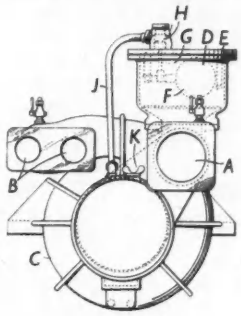
**706,319.** March 6, 1950.—REINFORCED CONCRETE, North Thames Gas Board and George Dougill, both of 30, Kensington Church Street, London, W.8.

An object of the invention is to obviate or minimise the corrosion of the ferrous reinforcement and thus to reduce the deterioration of structures with passage of time. There is provided a process for building a concrete structure reinforced with ferrous metal which includes applying to the ferrous reinforcement before or after assembly a concrete slurry containing a proportion of sodium benzoate. The whole mass of the concrete to be reinforced may contain a proportion of sodium benzoate, but in many cases it is preferred to introduce the sodium benzoate only into the layer or layers of concrete adjacent the ferrous reinforcement. The slurry containing the sodium benzoate is applied to the reinforcement and allowed to set before the main bulk of the concrete is poured. It may be applied by brushing or by dipping or by spraying or by "gunning." The sodium benzoate may be dissolved in the necessary amount in the water employed for making up the main bulk of the concrete or the slurry for coating the reinforcement. Alternatively, the water-soluble inhibitor can be employed in powdered form mixed, for example, with the cement prior to making up the mix or the slurry. Preferably there is used an aqueous solution containing between 2 and 10 per cent by weight of sodium benzoate. The ratio of cement to sand contained in the slurry may be from 1 : 2 to 1 : 3 by volume and two or more coats of the slurry may be applied to the ferrous reinforcement before the main bulk of the concrete is applied. Examples of the use of this method are also given in the specification.—*March* 31, 1954.

## PUMPS

**706,400.** May 22, 1950.—PRIMING OF CENTRIFUGAL PUMPS, John Kerr and Co. (Manchester), Ltd., Ashcroft Road, Kirkby Trading Estate, near Liverpool. (*Inventor: Henry George Clements.*)

The invention concerns centrifugal pumps (such as some types of fire pumps) in which a main pump is associated with a liquid-ring exhauster. The main pump body is mounted on a housing. The suction inlet is shown at *A*, and there are two side-by-side discharge outlets *B*. The exhauster or air pump *C* on the pump body is driven with the rotor of the main pump. On the top of the inlet port to the main pump a float chamber *D* is built. It is of rectangular form in plan and is joined to the suction port by flanges. The chamber is closed at the top by a lid or cover *E* from the underside of which is suspended a fulcrum float valve, comprising a ball float *F* and a needle valve *G*. In the boss above the needle valve is a non-return check valve *H*, above which again is a connection to a suction pipe *J* which leads to the suction side of the exhauster *C*. There is also a cock or tap *K* for breaking the load on the exhauster. In operation, when rotation of the pump and exhauster begins, the exhauster takes air from the main pump casing through the chamber *D*, valves *G* and *H*, connection and conduit *J*, the air being blown to exhaust. This extraction of air causes water to enter the main pump, through the suction port *A*, and this water eventually enters the chamber *D* and finally lifts the float *F* to shut the needle valve *G*. By this means the passing of water from the main pump to the exhauster is prevented. In the event that air is drawn into the suction conduit *A*, it will rise to the top of the chamber *D*, thereby depressing the level of the water unit and the consequent opening of the valve *G* will enable the exhauster to take that air away immediately. When the main pump has settled down to normal working, the relief valve *K* may be opened to unload the exhauster. A tank is provided containing water, which acts as a reservoir for the cooled water seal of the exhauster.—*March* 31, 1954.

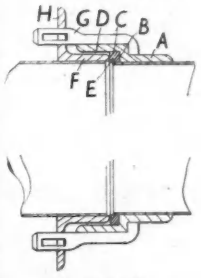



No. 706,400

## TUBE AND PIPE CONNECTIONS

**706,322.** September 6, 1950.—PIPE JOINTS, Joseph Gill, 7, Fair View Road, Dudley, Worcestershire.

The invention relates to pipe joints for ventilating pipes of comparatively large diameter. As will be seen from the drawing, the end of a sheet metal ventilating pipe is provided with a jointing ring in the form of a stepped sleeve *A*, which is welded to it. The end of the pipe projects beyond the internal shoulder *B* formed by the stepped sleeve, to form an annular groove *C* at the bottom of the socket *D* formed by the portion of the sleeve of enlarged diameter. The annular groove is fitted with a packing ring *E* and the ring is held in position ready for jointing two pipes together. The end of another pipe is fitted with a jointing ring in the form of a flanged sleeve *F*, which engages in the socket and bears against the front face of the packing ring to form a seal. The stepped sleeve *A* is provided at intervals around its outer periphery with projecting lugs or pins *G* with the L-shaped ends engaging behind the external shoulder on the stepped sleeve. The lugs pass through holes in the flange *H* on the end of the flanged sleeve and the two jointing rings are drawn together to make the joint by means of wedges, as indicated in the drawing. The length of the spigot is such that it can be engaged in the socket before the lugs are engaged in the perforations in the flanged sleeve, so that the pipe to be connected can first be placed in register and supported before it is moved inwards to make a joint. This arrangement considerably facilitates the erection of a pipeline.—*March* 31, 1954.

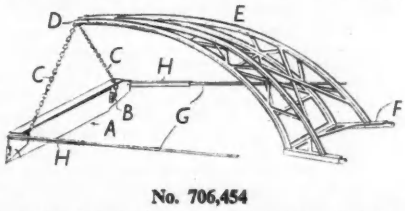



No. 706,322

## AGRICULTURAL ENGINEERING

**706,454.** March 11, 1952.—DITCH-CLEANING IMPLEMENT, Carter Bros. (Billingshurst), Ltd., "Reliance" Works, Billingshurst, Sussex; and Henry Boniface Sear, Street Farm, Fittleworth, near Pulborough, Sussex.

The invention is a ditch-cleaning implement for attachment to a tractor. As shown in the drawing, the dredger is formed as a metal plate scoop *A*, having a base, a back plate and side plates. Bolted to the inside of each side plate is a lug *B* for shackle chains *C*, which meet over a single shackle pin *D* in the head of

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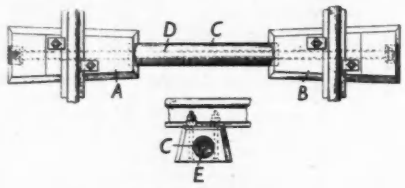
a lattice jib *E* and form a chain bridle suspension for the scoop. The foot *F* of the jib is framed to fit on lever arms of the power lift mechanism of a tractor. A pair of tubular steel shafts *G* are welded inside the angle of L cross section bars *H*, which are bolted to the side plates of the scoop. The shafts extend perpendicularly to the base of the scoop and are intended to be used in the manner of long rake handles. The length of the shafts is about equal to the reach of the jib, so that the shafts can be handled by men standing near the rear wheels of the tractor. For the use of the implement a team of three men is required.—*March* 31, 1954.

### RAILWAY ENGINEERING

**706,587.** December 10, 1951.—RAILROAD TIES OR SLEEPERS, Eugen Schulz and Ulrich Finsterwalder, sole responsible partners of Dyckerhoff and Widmann Kommanditgesellschaft, Lessingstrasse 9, Munich 15, Germany.

The invention relates to a railroad sleeper of prestressed reinforced concrete, composed of interconnected parts. The drawing shows a concrete

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railroad sleeper according to the invention. The tie comprises a pair of outer bearing members *A* and *B* of concrete, on which the rails of a track are secured. The central part *C* of the tie, also of concrete, is fashioned as a gauge bar and is rigidly connected as a non-articulated unit with the two bearing members. In each bearing member is a longitudinal hole registering with a corresponding hole of the middle part for reception of a steel rod *D* extending through the whole tie. The rod, through nuts and pressure plates, bears against the end faces of the bearing members, thus transmitting the tension forces to the whole tie, in the form of a corresponding compressive stress. Non-preloaded reinforcements for resisting transverse tensile stresses may be additionally provided in the bearing members. The fastenings for the rails are clearly shown in the drawing.—*March* 31, 1954.

## British Standards Institution

*All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.*

### SUMMARY OF FACE-TO-FACE DIMENSIONS OF FLANGED FERROUS VALVES FOR THE PETROLEUM INDUSTRY

No. 2080 : 1954. Price 6s.—This British Standard provides for the petroleum and petroleum equipment industry a convenient comparison of face-to-face and end-to-end dimensions of flanged ferrous valves with plain face, raised face or ring joint end flanges, as specified in the following British Standards, with their counterparts specified in American Standards, and with some other valves not yet standardised :—

B.S. 1414, "Flanged Steel Outside Screw and Yoke Wedge Gate Valves for the petroleum Industry."

B.S. 1570, "Flanged Steel Plug Valves for the Petroleum Industry."

B.S. 1655, "Flanged Automatic Control Valves for the Petroleum Industry (Face-to-Face Dimensions)."

B.S. 1735, "Flanged Cast Iron Gate Valves, Classes 125 and 250, for the Petroleum Industry."

B.S. 1868, "Flanged Steel Check Valves for the Petroleum Industry."

B.S. 1873, "Flanged Steel Globe Valves for the Petroleum Industry."

In addition to the tables listing dimensions in inches, companion tables are given listing the metric equivalent in millimetres. In view of the international character of the petroleum industry, it is believed that this information will enhance the usefulness of this standard.

### STEAM RECEIVERS AND SEPARATORS

No. 2079 : 1954. Price 12s. 6d. This is one of a series of standards for land boilers and unfired pressure vessels. It applies solely to steam receivers and separators used for piping installations for and in connection with land boilers, and is not intended to cover process vessels or steam receivers and separators, the design temperature of which exceeds 900 deg. Fah.

The standard applies to welded and riveted receivers and is divided into four main parts. The first part deals with definitions and information to be supplied by the purchaser and by the manufacturer. The second part deals with materials and includes specifications for plates, bars, sections and rivets, seamless shells, shells made from seamless rolled or drawn tube, branches, flanges, forgings and castings.

Part three deals with construction and workmanship and covers *inter alia* dished and flat ends, compensating rings, access openings and doors, branches and other connections. This part also lays down requirement for riveted shells, fusion welded shells and seamless forged shells. Details and requirements in respect of weld tests on the welded seams, heat-treatment, hydraulic and hammer tests are specified.

Part four deals with rules for scantlings and specifies minimum thicknesses for fusion welded shells and for shells other than fusion welded shells. Design stresses are given, together with requirements for end plates, manholes, branches, compensation for openings in shells, &c. Design requirements for riveted receivers are given in detail.

Two appendices to the specification illustrate typical methods of attachment for branches, pads and bosses secured by welding alone, and also typical acceptable methods of attachment of receiver ends.

### OLIVE, SOLDERED NIPPLE AND FLARED TYPES OF COPPER AND COPPER ALLOY TUBE FITTINGS FOR ENGINEERING PURPOSES

No. 2051, Part 2 : 1954. Price 12s. 6d. This new standard provides for the complete dimensional standardisation of the copper tube fittings known as olive, soldered nipple, flared and inverted flared fittings for use with copper and copper alloy and other suitable tube designated by its fractional O.D. size for a wide range of engineering purposes. It covers the following classes and ranges of fittings :—Olive fittings of sizes ranging from ¼in to ⅝in inclusive ; soldered nipple fittings of sizes ranging from ¼in to ⅝in inclusive ; flared fittings of sizes ranging from ¼in to 1in inclusive, and inverted flared fittings of sizes ranging from ¼in to ⅝in inclusive. These fittings are provided with "B.S.P. Whitworth" threads to B.S. 84 or Unified threads to B.S. 1580. Material requirements and tests for porosity are specified, and also details of the maximum working pressures for the fittings. Illustrations of the fittings, together with tables of dimensions of each, are included in the standard.

### RAILWAY ROLLING STOCK MATERIAL : COPPER

No. 24, Part 5 : 1954. Price 4s. This revised publication specifies requirements for copper in the following forms :—Copper plate for locomotive fireboxes ; copper rod for locomotive stay bolts, rivets, &c. ; copper tubes for locomotives.

In this revision, the requirements previously covered separately by Specifications Nos. 12 and 12*a* for rolled and extruded rod respectively, are incorporated in the one specifiation, No. 12, and those for copper tubes and pipes for locomotive boilers previously covered by Specifications Nos. 13 and 15, respectively, have been incorporated in Specification No. 13 under the title "Copper Tubes for Locomotives."

Specification No. 14, "Brass Tubes for Locomotive Boilers," which was included in the earlier edition of the standard has been omitted, as the small demand for brass tubes for locomotive boilers is met by the existing British Standard 885, "Brass Tubes for General Purposes."

Details of chemical composition have not been included, but reference has been made to B.S. 1173, "Tough Pitch Arsenical Copper" and B.S. 1174, Phosphorus Deoxidised Arsenical Copper," where appropriate, and copper complying with the latter standard has been permitted as an alternative to the former for rod material. In some cases tolerances and mechanical properties have been modified and a gassing or hydrogen embrittlement test has been added for deoxidised material in the form of plate and rod. Wherever possible the individual specifications have been modelled on the corresponding general-purpose standards, but the main requirements are substantially unaltered from the earlier edition.

## Launches and Trial Trips

SHELLMAC, asphalt carrier ; built by the Chantier de Normandie for the French Shell Company ; length between perpendiculars 216ft 6in, breadth moulded 36ft 11in, depth 13ft 8in, load draught 12ft 2in, displacement 2143 tons, deadweight 1180 tons, service speed 10 knots ; a triple-expansion steam engine having cylinders 380mm, 620mm and 1100mm in diameter by 500mm stroke, steam supplied by two cylindrical oil-fired boilers at 215 lb per square inch. Trial, April.

BRITISH SERGEANT, oil tanker ; built by Harland and Wolff, Ltd., for the British Tanker Company, Ltd. ; length between perpendiculars 490ft, breadth moulded 65ft, depth moulded 36ft, deadweight 14,000 tons ; twenty-seven cargo oil tanks, two pump rooms, two 125kW diesel-driven generators, one 50kW steam-driven generator ; Harland-B. and W. two-stroke, single-acting, opposed-piston diesel engine, six cylinders, 620mm diameter by 1870mm combined stroke, two single-ended multi-tubular boilers. Launch, April 14th.

## Forthcoming Engagements

*Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the* TIME AND PLACE *at which the meeting is to be held should be clearly stated.*

### COMBUSTION ENGINEERING ASSOCIATION

*Thurs. and Fri., May 6th and 7th.*—Grand Hotel, Harrogate, Annual Conference.

### ELECTRIC RAILWAY SOCIETY

*Thurs., May 6th.*—Fred Tallant Hall, 153, Drummond Street, London, N.W.1, "Manchester-Sheffield To-day," J. M. Clayton, 7.15 p.m.

### INCORPORATED PLANT ENGINEERS

*To-day, April 30th.*—BIRMINGHAM BRANCH : Imperial Hotel, Temple Street, Birmingham, "Welding," F. A. Thomas, 7.30 p.m.

### INSTITUTE OF MARINE ENGINEERS

*Mon., May 3rd.*—JUNIOR LECTURE : 85, Minories, London, E.C.3, "Marine Diesel Engines : Harland and Wolff Types," C. C. Pounder, 6.30 p.m.

### INSTITUTE OF NAVIGATION

*Wed., May 5th.*—Royal Geographical Society, 1, Kensington Gore, London, S.W.7, "13,000 Feet Under the Sea," G. S. Houot, 5 p.m.

### INSTITUTE OF PETROLEUM

*Fri., May 14th.*—26, Portland Place, London, W.1, Symposium on Medical Services in the Petroleum Industry, 5.30 p.m.

### INSTITUTE OF WELDING

*To-day and Sat., April 30th to May 1st.*—SPRING MEETING : To-day, April 30th, morning : Grand Hotel, Bristol, "Nitrogen-Arc Welding of Copper," E. Davis and C. A. Terry ; "Nitrogen-Arc Welding of Copper," K. Winterton ; afternoon : Choice of Works Visits ; evening : Grand Hotel, Bristol, Dinner.—Sat., May 1st, morning : Grand Hotel, Bristol, "Welding in the Aero-engine Industry : Reflections on Organisation by a Production Engineer," F. G. C. Sandiford ; "Welding as a Career," F. Koenigsberger.

### INSTITUTION OF CHEMICAL ENGINEERS

*To-day, April 30th.*—May Fair Hotel, Berkeley Street, London, W.1, Thirty-Second Annual Corporate Meeting, 11 a.m.

*Thurs. and Fri., May 6th and 7th.*—Holland, Joint Conference on "Unit Processes of Oxidation," with the Koninklijk Institute van Ingenieurs, the Chemical Section of the Netherlands Chemical Society and the Chmical Engineering Group of the Society of Chemical Industry.

### INSTITUTION OF CIVIL ENGINEERS

*To-day, April 30th.*—YORKSHIRE ASSOCIATION : Royal Victoria Station Hotel, Sheffield, Annual General Meeting, "Land Drainage in England and Wales," E. A. G. Johnson, 7 p.m.

*Tues., May 4th.*—PUBLIC HEALTH MEETING : Great George Street, Westminster, London, S.W.1, "River Severn Scheme for the Water Supply of Coventry," R. C. G. Hetherington and J. C. A. Roseveare, 5.30 p.m.

*Tues., May 11th.*—RAILWAY MEETING : Great George Street, Westminster, London, S.W.1, "Wear of Steel Rails : a Review of the Factors Involved," J. Dearden, 5.30 p.m.

*Thurs., May 13th.*—MIDLANDS ASSOCIATION : James Watt Memorial Institute, Great Charles Street, Birmingham, Annual General Meeting, 5.30 p.m.——N.W. ASSOCIATION: Engineers' Club, Albert Square, Manchester, Annual General Meeting, 6.30 p.m.

### INSTITUTION OF ELECTRICAL ENGINEERS

*Mon., May 3rd.*—S. MIDLAND CENTRE : James Watt Memorial Institute, Great Charles Street, Birmingham, "Safety in the Use of Portable and Transportable Electrical Equipment in Industry," J. W. Bunting, 6 p.m.

*Tues., May 4th.*—N. MIDLAND CENTRE : British Electricity Authority, 1, Whitehall Road, Leeds, 1, Annual General Meeting, 6.30 p.m.

*Wed., May 5th.*—RADIO SECTION : Savoy Place, London, W.C.2, "The Reflection and Absorption of Radio Waves in the Ionosphere," W. R. Piggott ; "Some Notes on the Absorption of Radio Waves Reflected from the Ionosphere at Oblique Incidence," W. J. G. Beynon, 5.30 p.m.——S.W. SCOTLAND SUB-CENTRE : Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, Annual General Meeting, 7 p.m.

*Thurs., May 6th.*—ORDINARY MEETING : Savoy Place, London, W.C.2, "Electric Traction Using Single-Phase 50 c/s Current," M. Garreau ; "Electric Locomotives on the Valenciennes-Thionville Line," F. Nouvion, 5.30 p.m.

### INSTITUTION OF MECHANICAL ENGINEERS

*To-day, April 30th.*—GENERAL MEETING, AUTOMOBILE DIVISION AND APPLIED MECHANICS GROUP : 1, Birdcage Walk, Westminster, London, S.W.1, "Nodular Cast Iron : Its Present Position and Future Prospects as an Engineering Material," S. B. Bailey, 5.30 p.m.

*Tues., May 4th.*—GENERAL MEETING : 1, Birdcage Walk, Westminster, London, S.W.1, "The Development and Scope of Work Study," R. M. Currie, 5.30 p.m.——LONDON GRADUATES' SECTION : 1, Birdcage Walk, Westminster, London, S.W.1, Annual General Meeting, "Standardisation," R. F. Holmes, 6.30 p.m.

*Fri., May 7th.*—GENERAL MEETING : 1, Birdcage Walk, Westminster, London, S.W.1, "The Accountancy Service to Works Management," C. E. Power, 5.30 p.m.——S. WALES BRANCH : Mackworth Hotel, Swansea, "Combustion in Compression-Ignition Oil Engines," S. J. Davies, 6 p.m.

### INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

*Tues., May 4th.*—ORDINARY MEETING : Institution of Electrical Engineers, Savoy Place, London, W.C.2, "Short-Wave Directional Aerial Systems," D. W. Morris, W. G. Shaddick and E. W. Thurlow, 5 p.m.

### INSTITUTION OF PRODUCTION ENGINEERS

*Sat., May 1st.*—YORKSHIRE GRADUATE SECTION : Great Northern Hotel, Leeds, Annual General Meeting, Films, 2.30 p.m.

*Wed., May 5th.*—NOTTINGHAM SECTION : Visit to the Works Showroom of the Austin Motor Co., Ltd., Longbridge Works, Birmingham, 10.30 a.m.

### ROYAL AERONAUTICAL SOCIETY

*Tues., May 4th.*—SECTION LECTURE : 4, Hamilton Place, London, W.1, "Propellers for High-Speed Aircraft," G. C. I. Gardiner 7 p.m.

### ROYAL INSTITUTION OF CHARTERED SURVEYORS

*Mon., May 3rd.*—ORDINARY GENERAL MEETING : 12, Great George Street, Westminster, London, S.W.1, "The Changing Constitution," R. G. Fitzgerald, 5.30 p.m.

### SOCIETY OF CHEMICAL INDUSTRY

*Tues., May 4th.*—Burlington House, Piccadilly, London, W.1, Annual General Meeting, 6.30 p.m.